

Faculty of Electrical Engineering and Information Technology

# Module Handbook

for the Master Program

## Electrical Engineering and Information Technology

Version from 06. September 2023

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# 1 Compulsory Modules

## 1.1 Digital Communication Systems

|  |   |
|--|---|
| English title                                  | Digital Communication Systems   |
| Qualification goals and contents of the module | <b>Learning objectives and acquired competences:</b><br>The Student will <ul style="list-style-type: none"><li>• gain knowledge about the functions and properties of digital communication systems.</li><li>• understand the physical principles underlying digital communication.</li><li>• gain knowledge about the modern wired and wireless digital communication standards.</li></ul> <b>Contents:</b> <ul style="list-style-type: none"><li>• Introduction</li><li>• Signal representation</li><li>• Stochastic processes and noise</li><li>• Sampling, quantization, and coding</li><li>• Transmission bandwidth, data rate, and channel capacity</li><li>• Calculation of error rates</li><li>• PCM, ASK, PSK, and FSK modulation techniques</li><li>• OFDM and CDMA</li><li>• Modeling of wireless channels</li></ul> |
| Literature                                     | [1] Jerry D. Gibson: Principles of Digital and Analog Communications. Macmillian Publishing Company, 1989, ISBN 0-02-341780-3   |
| Language                                       | English   |
| Forms of teaching                              | Lecture, Exercise   |
| Requirements for participation                 | Bachelor in Electrical Engineering or related studies   |
| Usability of the module                        | Compulsory module for the Master Course "Electrical Engineering and Information Technology".  |
| Examinations prerequisite                      | None  |
| Exam performance                               | Written exam 120 minutes at the end of the module   |
| Credit points and grades                       | 3 SWS / 5 CP = 150 h (42 h time of attendance + 108 h autonomous work)<br>Grading scale as per examination regulations  |
| Work effort                                    | Time of attendance: 2 SWS Lecture, 1 SWS Exercise<br>Autonomous work: Post processing of lectures, solving of exercises, research report and preparation of exam  |
| Availability                                   | Every year in the summer semester   |
| Duration of the module                         | One Semester  |
| Responsible lecturer                           | Prof. Dr.-Ing. habil. Holger Maune (FEIT-IIKT)  |

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## 1.2 Digital Information Processing

|  |   |
|--|---|
| English title                                  | Digital Information Processing  |
| Qualification goals and contents of the module | <p><b>Learning objectives and acquired competences:</b></p> <ul style="list-style-type: none"> <li>• The participant has an overview of basic problems and methods of digital signal processing.</li> <li>• The participant understands the functionality of a digital signal processing system and can mathematically explain the modus of operation.</li> <li>• The participant can assess applications in terms of stability and other markers. He / She can calculate the frequency response and reconstruction of analogue signals.</li> <li>• The participant can perform these calculations and assessments as well on stochastically excited digital systems.</li> <li>• The participant can apply this knowledge in a field of specialization, e.g. Medical Signal Analysis.</li> </ul> <p><b>Contents:</b></p> <ul style="list-style-type: none"> <li>• Digital Signals and Digital LTI Systems</li> <li>• Z-Transform and Calculations of Inverse Z-Transforms</li> <li>• System Analysis by Difference Equations</li> <li>• Sampling and Reconstruction</li> <li>• Synthesis and analysis of such systems</li> <li>• Discrete and Fast Fourier Transformations</li> <li>• Processing of Stochastic Signals by LTI-Systems: Correlation Techniques and Model-Based Systems (ARMA). Selected Specialization Topics, e.g. Medical Signal Analysis</li> </ul> |
| Literature                                     | <p>[1] Oppenheim, A; Schafer R (2013): "Discrete Time Signal Processing", 1056 pages, Pearson, ISBN: 978-1292025728</p> <p>[2] Lathi, B P; Green, R A (2014) "Essentials of Digital Signal Processing", 748 pages, Cambridge University Press, ISBN: 978-1-107-05932-0</p>  |
| Language                                       | English   |
| Forms of teaching                              | Lecture, Exercise   |
| Requirements for participation                 | Bachelor in Electrical Engineering or related studies<br>Knowledge of signals and systems, Analog Fourier transformations   |
| Usability of the module                        | Master Courses in the Faculty of Electrical Engineering and Information Technology, and other Master Courses.   |
| Examinations prerequisite                      | Mandatory participation in exercise classes, successful results in exercises  |
| Exam performance                               | Written exam 120 minutes at the end of the module   |
| Credit points and grades                       | 3 SWS / 5 CP = 150 h (42 h time of attendance + 108 h autonomous work)<br>Grading scale as per examination regulations  |
| Work effort                                    | Time of attendance: 2 SWS Lecture, 1 SWS Exercise<br>Autonomous work: Post processing of lectures, solving of exercises and preparation of exam   |
| Availability                                   | Every year in the winter semester   |
| Duration of the module                         | One Semester  |
| Responsible lecturer                           | Prof. Dr. rer. nat. Andreas Wendemuth (FEIT-IIKT)   |

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## 1.3 Electromagnetic Field Theory

|  |  |
|--|--|
| English title                                  | Electromagnetic Field Theory   |
| Qualification goals and contents of the module | <p><b>Learning objectives and acquired competences:</b><br/>The Student</p> <ul style="list-style-type: none"> <li>• will know mathematical basics (vector analysis, operators and integral theorems).</li> <li>• know and understand fundamental laws of electromagnetics, constituting the system of Maxwell's field equations and the boundary conditions for the different fields.</li> <li>• learn how to solve basic problems for static and dynamic fields.</li> </ul> <p><b>Contents:</b></p> <ul style="list-style-type: none"> <li>• Mathematical fundamentals</li> <li>• Static electric fields</li> <li>• Stationary currents and the static magnetic field</li> <li>• Time-varying electromagnetic</li> </ul> |
| Literature                                     | [1] J.A. Edminster, Schaum's Outline of Electromagnetics - (Schaum's Outline Series), McGraw-Hill Book Company   |
| Language                                       | English  |
| Forms of teaching                              | Lecture, Exercise  |
| Requirements for participation                 | Bachelor in Electrical Engineering or related studies  |
| Usability of the module                        | Compulsory module for the Master Course "Electrical Engineering and Information Technology".   |
| Examinations prerequisite                      | None   |
| Exam performance                               | Written exam 120 minutes at the end of the module  |
| Credit points and grades                       | 3 SWS / 5 CP = 150 h (42 h time of attendance + 108 h autonomous work)<br>Grading scale as per examination regulations   |
| Work effort                                    | Time of attendance: 2 SWS Lecture, 1 SWS Exercise<br>Autonomous work: Post processing of lectures, solving of exercises and preparation of exam  |
| Availability                                   | Every year in the winter semester  |
| Duration of the module                         | One Semester   |
| Responsible lecturer                           | Prof. Dr.-Ing. Marco Leone (FEIT-IMT)  |

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## 1.4 Electronic Circuits

|  |   |
|--|---|
| English title                                  | Electronic Circuits   |
| Qualification goals and contents of the module | <p><b>Learning objectives and acquired competences:</b><br/>The Student will</p> <ul style="list-style-type: none"> <li>• understand the main function principles on the interface between analog and digital circuit design.</li> <li>• have an overview about the realization of some complex function blocks.</li> </ul> <p><b>Contents:</b></p> <ul style="list-style-type: none"> <li>• digital analog converters: methods, characteristics, errors, applications</li> <li>• analog digital converters: classification, methods, characteristics, errors, applications</li> <li>• phase locked loops: principle, linear model, circuit design of the function blocks, applications</li> <li>• characteristics, circuit design of some function blocks, design process, introduction VHDL</li> <li>• design and test of digital circuits with programmable logic devices</li> </ul> |
| Literature                                     | <p>[1] U. Tietze, C. Schenk, D. Gamm: Electronic Circuits: Handbook for Design and Applications</p> <p>[2] Springer R. Best: Phase-Locked Loops: Design, Simulation and Applications</p>  |
| Language                                       | English   |
| Forms of teaching                              | Lecture, Exercise/Laboratory Internship   |
| Requirements for participation                 | Bachelor in Electrical Engineering or related studies   |
| Usability of the module                        | Compulsory module in the Master Course "Electrical Engineering and Information Technology".   |
| Examinations prerequisites                     | None  |
| Exam performance                               | Oral test at the end of the module  |
| Credit points and grades                       | 3 SWS / 5 CP = 150 h (42 h time of attendance + 108 h autonomous work)<br>Grading scale as per examination regulations  |
| Work effort                                    | Time of attendance: 2 SWS Lecture, 1 SWS Exercise/Laboratory Internship<br>Autonomous work: Post processing of lectures, solving of exercises, laboratory work, research report and preparation of exam   |
| Availability                                   | Every year in the winter semester   |
| Duration of the module                         | One Semester  |
| Responsible lecturer                           | Dipl.-Ing. Helmut Bresch (FEIT-IIKT)  |

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## 1.5 Power Electronics

|  |   |
|--|---|
| English title                                  | Power Electronics   |
| Qualification goals and contents of the module | <p><b>Learning objectives and acquired competences:</b><br/>           Knowledge about important power electronic circuits shall be imparted. Major methods to understand power electronic circuits are practised. Applications will be demonstrated in the exercise. Cross-links to related fields of electrical and information engineering will be shown.</p> <p><b>Contents:</b></p> <ul style="list-style-type: none"> <li>• choppers, buck chopper, boost chopper, phase leg</li> <li>• self commutated bridges with constant voltage DC link, H-bridge, three phase bridge</li> <li>• rectifiers, single and three phase, uncontrolled, half controlled, controlled</li> <li>• AC controllers</li> </ul> |
| Literature                                     | [1] Ned Mohan: Power electronics - converters, applications and design; Wiley, Hoboken NJ, 3rd edition 2003   |
| Language                                       | English   |
| Forms of teaching                              | Lecture, Exercise   |
| Requirements for participation                 | Bachelor in Electrical Engineering or related studies, comprising, fundamentals of electrical engineering, electronics – circuit theory, fundamentals of semiconductor components, mathematics  |
| Usability of the module                        | Compulsory module for the Master Course “Electrical Engineering and Information Technology” belonging to the field of electrical.   |
| Examinations prerequisite                      | None  |
| Exam performance                               | Written exam 120 minutes without auxiliaries at the end of the module   |
| Credit points and grades                       | 3 SWS / 5 CP = 150 h (42 h time of attendance + 108 h autonomous work)<br>Grading scale as per examination regulations  |
| Work effort                                    | Time of attendance: 2 SWS Lecture, 1 SWS Exercise<br>Autonomous work: Post processing of lectures, solving of exercises and preparation of exam   |
| Availability                                   | Every year in the winter semester   |
| Duration of the module                         | One Semester  |
| Responsible lecturer                           | Prof. Dr.-Ing. Andreas Lindemann (FEIT-IESY)  |

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## 1.6 Power Network Planning (and Operation)

|  |   |
|--|---|
| English title                                  | Power Network Planning (and Operation)  |
| Qualification goals and contents of the module | <p><b>Learning objectives and acquired competences:</b><br/>The student will learn about steady-state and quasi-stationary algorithms to model and calculate grid states for the purpose of power system planning and operation. This includes the modelling of topology and equipment in natural and modal components, power flow calculation, state estimation, stability and short-circuit calculations as well as modelling of shunt and series faults.</p> <p><b>Contents:</b></p> <ul style="list-style-type: none"> <li>• Introduction to the tasks of network planning and system operation</li> <li>• Equation systems to describe steady-state and quasi-steady-state problems in electric power networks</li> <li>• Grid modeling using modal component systems</li> <li>• Basic algorithms of power flow, short-circuit and stability calculations as well as state estimation</li> <li>• Introduction to power grid modelling with MATLAB</li> </ul> |
| Literature                                     | <p>[1] „Electric Power System Planning“, H. Seifi, M.S. Sepasian, Springer-Verlag, 2011</p> <p>[2] „Power system engineering : planning, design, and operation of power systems and equipment“, Juergen Schlabbach. - Weinheim : WILEY-VCH, 2008</p>  |
| Language                                       | English   |
| Forms of teaching                              | Lecture, Exercise   |
| Requirements for participation                 | Bachelor in Electrical Engineering or related studies   |
| Usability of the module                        | Compulsory module for the Master Course “Electrical Engineering and Information Technology”.  |
| Examinations prerequisite                      | None  |
| Exam performance                               | Written exam 120 minutes at the end of the module   |
| Credit points and grades                       | 3 SWS / 5 CP = 150 h (42 h time of attendance + 108 h autonomous work)<br>Grading scale as per examination regulations  |
| Work effort                                    | Time of attendance: 2 SWS Lecture, 1 SWS Exercise<br>Autonomous work: Post processing of lectures, solving of exercises and preparation of exam   |
| Availability                                   | Every year in the winter semester   |
| Duration of the module                         | One Semester  |
| Responsible lecturer                           | Prof. Dr.-Ing. habil. Martin Wolter (FEIT-IESY)   |

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## 1.7 Project

| English title                                  | Project   |              |       |          |                  |    |   |    |  |          |        |
|--|---|--------------|-------|----------|------------------|----|---|----|--|----------|--------|
| Qualification goals and contents of the module | <p><b>Learning objectives and acquired competences:</b></p> <ul style="list-style-type: none"> <li>• The student knows the typical processes and techniques of scientific work. After passing the module, the student is able to analyze the current state of science and technology and to develop own scientific project ideas. The student can perform a market analysis, develop project specifications and write a scientific project report.</li> <li>• The student knows the basic rules of scientific writing. After completing the module, the student is able to structure a report or thesis, to create significant plots and figures, and to cite all used sources. The student is very well aware of the problem of plagiarism. The student is also able to defend his project results in an oral presentation.</li> </ul> <p><b>Contents:</b></p> <p><b>Part 1 (Non-technical Project Seminar)</b><br/>The seminar consists of four lectures with the topics</p> <ul style="list-style-type: none"> <li>• Literature survey and reference management</li> <li>• Rules of scientific writing, Visualization, schematics and diagrams</li> <li>• Effective oral presentations, writing a short paper (1 page) and giving a short presentation (5 minutes) about a given topic</li> </ul> <p><b>Part 2 (Non-technical Project Work)</b></p> <ul style="list-style-type: none"> <li>• Application of the obtained skills on a specific topic under supervision of the project supervisor</li> </ul> <p><b>Schedule</b></p> <table border="1"> <thead> <tr> <th>Lecture Week</th> <th>Event</th> </tr> </thead> <tbody> <tr> <td>01 to 04</td> <td>Lectures of part</td> </tr> <tr> <td>05</td> <td>Short paper submission/review of part 1</td> </tr> <tr> <td>06</td> <td>Short presentations of part 1, issue of the certificates of attendance of part 1</td> </tr> <tr> <td>07 to 14</td> <td>Part 2</td> </tr> </tbody> </table> | Lecture Week | Event | 01 to 04 | Lectures of part | 05 | Short paper submission/review of part 1 | 06 | Short presentations of part 1, issue of the certificates of attendance of part 1 | 07 to 14 | Part 2 |
| Lecture Week                                   | Event   |              |       |          |                  |    |   |    |  |          |        |
| 01 to 04                                       | Lectures of part  |              |       |          |                  |    |   |    |  |          |        |
| 05   | Short paper submission/review of part 1   |              |       |          |                  |    |   |    |  |          |        |
| 06   | Short presentations of part 1, issue of the certificates of attendance of part 1  |              |       |          |                  |    |   |    |  |          |        |
| 07 to 14                                       | Part 2  |              |       |          |                  |    |   |    |  |          |        |
| Literature                                     | [1] R. C. Dorf, R. H. Bishop: Modern Control Systems, Pearson Education, 2005   |              |       |          |                  |    |   |    |  |          |        |
| Language                                       | English   |              |       |          |                  |    |   |    |  |          |        |
| Forms of teaching                              | Research project  |              |       |          |                  |    |   |    |  |          |        |
| Requirements for participation                 | Part 2 of the module can only be attended if the part 1 was successfully passed   |              |       |          |                  |    |   |    |  |          |        |
| Usability of the module                        | Compulsory module for the Master's course "Electrical Engineering and Information Technology".  |              |       |          |                  |    |   |    |  |          |        |
| Examinations prerequisite                      | None  |              |       |          |                  |    |   |    |  |          |        |
| Exam performance                               | Research project (PRO)  |              |       |          |                  |    |   |    |  |          |        |
| Credit points and grades                       | 5 CP = 150 h<br>Grading scale as per examination regulations  |              |       |          |                  |    |   |    |  |          |        |
| Work effort                                    | The first part of the module is accounted with 12 hours of attendance and 8 hours of autonomous work. The remaining time for the second part of the module is then 30 hours of attendance and 100 hours of autonomous work.   |              |       |          |                  |    |   |    |  |          |        |
| Availability                                   | Every year in the summer semester   |              |       |          |                  |    |   |    |  |          |        |
| Duration of the module                         | One Semester  |              |       |          |                  |    |   |    |  |          |        |
| Responsible lecturer                           | Dr.-Ing. Magdowski (FEIT-IMT) in conjunction with work supervisor   |              |       |          |                  |    |   |    |  |          |        |

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## 1.8 Systems and Control

|  |   |
|--|---|
| English title                                  | Systems and Control   |
| Qualification goals and contents of the module | <p><b>Learning objectives and acquired competences:</b><br/>The student will learn how to</p> <ul style="list-style-type: none"> <li>• mathematically describe and analyses dynamic systems.</li> <li>• design feedback control systems using frequency and time domain techniques.</li> <li>• efficiently apply modern software tools to achieve the aforementioned goals.</li> </ul> <p><b>Contents:</b></p> <ul style="list-style-type: none"> <li>• Introduction to control systems</li> <li>• Mathematical models of systems</li> <li>• Feedback control systems characteristics</li> <li>• The performance of feedback control systems</li> <li>• The stability of linear feedback systems</li> <li>• The root locus method</li> <li>• Frequency response method</li> <li>• The design of state variable feedback systems (Full-state feedback design and observer design methods)</li> </ul> |
| Literature                                     | [1] R. C. Dorf, R. H. Bishop: Modern Control Systems, Pearson Education, 2005   |
| Language                                       | English   |
| Forms of teaching                              | Lecture, Exercise   |
| Requirements for participation                 | Bachelor in Electrical Engineering or related studies   |
| Usability of the module                        | Compulsory module for the Master's course "Electrical Engineering and Information Technology", optional module for students of the "International Max-Planck Research School" and the Master's course "Chemical Process Engineering".   |
| Examinations prerequisite                      | None  |
| Exam performance                               | Written exam 120 minutes at the end of the module   |
| Credit points and grades                       | 3 SWS / 5 CP = 150 h (42 h time of attendance + 108 h autonomous work)<br>Grading scale as per examination regulations  |
| Work effort                                    | Time of attendance: 2 SWS Lecture, 1 SWS Exercise<br>Autonomous work: Post processing of lectures, solving of exercises and preparation of exam   |
| Availability                                   | Every year in the winter semester   |
| Duration of the module                         | One Semester  |
| Responsible lecturer                           | Prof. Dr.-Ing. habil. Achim Kienle (FEIT-IFAT)  |

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## 2 Technical Elective Modules

### 2.1 Field of Study Automation Systems

#### 2.1.1 Automation Lab

|  |   |
|--|---|
| English title                                  | Automation Lab  |
| Qualification goals and contents of the module | <b>Learning objectives and acquired competences:</b><br>To develop practical skills in the field of (process) automation.<br><br><b>Contents:</b><br>The acquired knowledge from the courses “Systems and Control” and “Distributed Control Systems” should be applied to practical examples/systems of automation. For these purposes miscellaneous experiments will be conducted. |
| Literature                                     | According to modules "Systems and Control" and "Distributed Control Systems"  |
| Language                                       | English   |
| Forms of teaching                              | Laboratory Internship   |
| Requirements for participation                 | Bachelor in Electrical Engineering or related studies, Systems and Control, Distributed Control Systems   |
| Usability of the module                        | Compulsory elective module for the Master Course “Electrical Engineering and Information Technology”.   |
| Examinations prerequisite                      | None  |
| Exam performance                               | Oral test after every experiment  |
| Credit points and grades                       | 2 SWS / 5 CP = 150 h (28 h time of attendance + 122 h autonomous work)<br>Grading scale as per examination regulations  |
| Work effort                                    | Time of attendance: 2 SWS Laboratory Internship<br>Autonomous work: Post processing and preparation of Laboratory Internship  |
| Availability                                   | Every year in the winter semester   |
| Duration of the module                         | One Semester  |
| Responsible lecturer                           | Prof. Dr.-Ing. habil. Achim Kienle (FEIT-IFAT)  |

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## 2.1.2 Digital Automation Systems

|  |   |
|--|---|
| English title                                  | Digital Automation Systems  |
| Qualification goals and contents of the module | <p><b>Learning objectives and acquired competences:</b><br/>At the end of the course, the students will have core competencies in the design and construction of distributed digital automation systems. They will understand how to plan and implement the integration of various automation components and which automation and information technologies are used. Students acquire the ability to recognize and interpret abstract automation and information technology models and to grasp their interrelations in order to create functional automation systems. Through the exercises, the students are able to deepen their knowledge and skills in a research-oriented way and to apply and evaluate them in complex problems.</p> <p><b>Contents:</b></p> <ul style="list-style-type: none"> <li>• Models and methods for handling automation systems</li> <li>• Information models</li> <li>• Integration technologies</li> <li>• Principles of descriptive description methods for technical systems</li> </ul> |
| Literature                                     | <p>[1] Wolfgang Mahnke, Stefan-Helmut Leitner, Matthias Damm: OPC Unified Architecture. Springer-Verlag Berlin Heidelberg 2009. ISBN 978-3-540-68898-3, DOI 10.1007/978-3-540-68899-0, e-ISBN 978-3-540-68899-0</p> <p>[2] Riedl, M., Naumann, F.: EDDL. Vulkan-Verlag. ISBN-10: 3835632434. Standard books UML and XML.</p>  |
| Language                                       | English   |
| Forms of teaching                              | Lecture, Exercise   |
| Requirements for participation                 | Bachelor in Electrical Engineering, Computer Science or related studies   |
| Usability of the module                        | Compulsory elective module for the Master Course "Electrical Engineering and Information Technology" and "Digital Engineering".   |
| Examinations prerequisite                      | None  |
| Exam performance                               | Written exam 90 minutes at the end of the module  |
| Credit points and grades                       | 3 SWS / 5 CP = 150 h (42 h time of attendance + 108 h autonomous work)<br>Grading scale as per examination regulations  |
| Work effort                                    | Time of attendance: 2 SWS Lecture, 1 SWS Exercise<br>Autonomous work: Post processing of lectures, solving of exercises, preparation of presentation and exam   |
| Availability                                   | Every year in the winter semester   |
| Duration of the module                         | One Semester  |
| Responsible lecturer                           | Prof. Dr.-Ing. Christian Diedrich (FEIT-IFAT)   |

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### 2.1.3 Non-linear Control

|  |   |
|--|---|
| English title                                  | Non-linear Control  |
| Qualification goals and contents of the module | <p><b>Learning objectives and acquired competences:</b><br/>The students will be able to describe and model nonlinear systems, to analyze the system dynamic behaviour such as stability considering different stability concepts, and to design controllers for nonlinear systems.</p> <p><b>Contents:</b></p> <ul style="list-style-type: none"> <li>• Review of mathematical basics</li> <li>• Review of linear MIMO systems</li> <li>• Lyapunov stability</li> <li>• Concepts of BIBO stability</li> <li>• Passivity</li> <li>• I/O linearization</li> <li>• Design of controllers for nonlinear systems</li> </ul> |
| Literature                                     | <p>[1] D.E. Kirk. Optimal Control Theory – An Introduction. Prentice-Hall Inc., Englewood Cliffs, New Jersey, 2004</p> <p>[2] D.P. Bertsekas. Dynamic Programming and Optimal Control, volume 1. Athena Scientific Press, Belmont, MA, 2006</p> <p>[3] R. Bellman. Dynamic Programming. Princeton University Press, Princeton, New Jersey, 1957</p>   |
| Language                                       | English   |
| Forms of teaching                              | Lecture, Exercise/Tutorial  |
| Requirements for participation                 | Knowledge in control theory   |
| Usability of the module                        | Compulsory elective module for the Master Courses “Systemtechnik und Technische Kybernetik”.<br>Compulsory elective module for the Master Course “Electrical Engineering and Information Technology”.   |
| Examinations prerequisite                      | None  |
| Exam performance                               | Oral test at the end of the module and project report   |
| Credit points and grades                       | 3 SWS / 5 CP = 150 h (42 h time of attendance + 108 h autonomous work)<br>Grading scale as per examination regulations  |
| Work effort                                    | time of attendance: 2 SWS Lecture, 1 SWS Exercise/Tutorial<br>autonomous work: Post processing of lectures, preparation of project work/report and exam   |
| Availability                                   | Every year in the summer semester   |
| Duration of the module                         | One Semester  |
| Responsible lecturer                           | PD Dr. sc. techn. ETH Eric Bullinger (FEIT-IFAT)  |

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## 2.1.4 Process Control

|  |  |
|--|--|
| English title                                  | Process Control  |
| Qualification goals and contents of the module | <p><b>Learning objectives and acquired competences:</b><br/>Students should</p> <ul style="list-style-type: none"> <li>• learn fundamentals of multivariable process control with special emphasis on decentralized control</li> <li>• gain the ability to apply the above mentioned methods for the control of single and multi unit processes</li> <li>• gain the ability to apply advanced software (MATLAB) for computeraided control system design</li> </ul> <p><b>Contents:</b></p> <ol style="list-style-type: none"> <li>1. Introduction</li> <li>2. Process control fundamentals <ul style="list-style-type: none"> <li>• Mathematical models of processes</li> <li>• Control structures</li> <li>• Decentralized control and Relative gain analysis</li> <li>• Tuning of decentralized controllers</li> <li>• Control implementation issues</li> </ul> </li> <li>3. Case studies</li> <li>4. Plantwide control</li> </ol> |
| Literature                                     | [1] B. W. Bequette: Process Control, Modeling Design and Simulation, Pearson Education, 2003   |
| Language                                       | English  |
| Forms of teaching                              | Lecture, Exercise/Tutorial   |
| Requirements for participation                 | Basic knowledge in control theory  |
| Usability of the module                        | Compulsory module for the Master Course "Elektrotechnik und Informationstechnik" Option "Automatisierungstechnik".<br>Optional module for the Master Courses "Systemtechnik und Technische Kybernetik" and "Chemical Process Engineering", for students of the International Max-Planck Research School.<br>Compulsory elective module for the Master Course "Electrical Engineering and Information Technology".  |
| Examinations prerequisite                      | None   |
| Exam performance                               | Oral test at the end of the module and project report  |
| Credit points and grades                       | 3 SWS / 5 CP = 150 h (42 h time of attendance + 108 h autonomous work)<br>Grading scale as per examination regulations   |
| Work effort                                    | Time of attendance: 2 SWS Lecture, 1 SWS Exercise/Tutorial<br>Autonomous work: Post processing of lectures, preparation of project work/report and exam  |
| Availability                                   | Every year in the summer semester  |
| Duration of the module                         | One Semester   |
| Responsible lecturer                           | Prof. Dr.-Ing. habil. Achim Kienle (FEIT-IFAT)   |

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## 2.1.5 State Estimation

|  |  |
|--|--|
| English title                                  | State Estimation   |
| Qualification goals and contents of the module | <p><b>Learning objectives and acquired competences:</b><br/> The module provides an introduction to state estimation and model based measurement systems. The students are enabled to judge whether the available measurement data are sufficient to reconstruct all states of a process model, or which additional measurement information is required. At the end of the course the students are able to choose suitable state estimation techniques for linear and nonlinear systems. Special emphasis is on the Kalman filter. The students are enabled to derive the filter equations, to implement them and to choose the tuning parameters.</p> <p>The acquired knowledge is deepened in computer exercises. In mini-projects, the students obtain practical experience in programming and testing state estimation algorithms.</p> <p><b>Contents:</b></p> <ul style="list-style-type: none"> <li>• Observability criteria for LTI systems</li> <li>• Luenberger observers for LTI systems with one or several measurements</li> <li>• Kalman filter for linear time-discrete systems</li> <li>• Kalman filter for linear time-continuous systems</li> <li>• Extended Kalman filter for nonlinear time-discrete and time-continuous systems</li> <li>• Unscented Kalman filter</li> <li>• Kalman filter with constrained filter update</li> <li>• Bayesian estimators</li> <li>• Outlook on observers for nonlinear systems</li> </ul> |
| Literature                                     | <p>[1] A. Gelb, Applied Optimal Estimation, M.I.T. Press, 1974.<br/> [2] D. Luenberger, Introduction to Dynamic Systems. Wiley, 1979.<br/> [3] D. Simon, Optimal State Estimation, John Wiley, 2006.</p>   |
| Language                                       | English  |
| Forms of teaching                              | Lecture, Exercise  |
| Requirements for participation                 | Basic subjects of the bachelor's degree  |
| Usability of the module                        | Compulsory elective module for various master's degree programs at the OvGU and for students of the International Max Planck Research School   |
| Examinations prerequisite                      | None   |
| Exam performance                               | Written exam 90 minutes at the end of the module   |
| Credit points and grades                       | 4 SWS / 5 CP = 150 h (56 h time of attendance + 94 h autonomous work)<br>Grading scale as per examination regulations  |
| Work effort                                    | Time of attendance: 2 SWS Lecture, 2 SWS Exercise<br>Autonomous work: Following up on lectures, solving exercises/project tasks, preparing for the exam  |
| Availability                                   | Every year in the summer semester  |
| Duration of the module                         | One Semester   |
| Responsible lecturer                           | Dr.-Ing. Christian Kunde (FEIT-IFAT)   |

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## 2.2 Field of Study Information and Communication Technology

### 2.2.1 Computed Tomography I - Methods on CT

|  |  |
|--|--|
| English title                                  | Computed Tomography I - Methods on CT  |
| Qualification goals and contents of the module | <p><b>Learning objectives and acquired competences:</b><br/>The student will</p> <ul style="list-style-type: none"><li>• understand the system theory of imaging systems.</li><li>• learn the functional principle of the computed tomography.</li><li>• understand the mathematical principle of tomographic reconstruction.</li><li>• have an overview about the current research work in the area of tomographic imaging.</li></ul> <p><b>Contents:</b><br/>Starting with the system theory of imaging systems, the first part of the module is focused on the physical properties of x-rays and their interaction with matter. The second part deals with X-ray based standard radiography. The third and final part brings the mathematical methods of tomographic image reconstruction into focus. The particular content is:</p> <ul style="list-style-type: none"><li>• System theory of imaging systems</li><li>• Basic principle of underlying physics</li><li>• X-ray tubes and detectors</li><li>• Radiography</li><li>• Reconstruction: Fourier-based principle, Filtered back projection, Algebraic approach, statistical methods</li><li>• Beam-geometry: Parallel-, Fan- and Cone beam</li><li>• Implementation</li><li>• Artefacts and Adjustment</li></ul> |
| Literature                                     | [1] Kak, Slaney: Principles of computerized tomographic imaging; Kalender: Computed Tomography   |
| Language                                       | English  |
| Forms of teaching                              | Lecture, Tutorial  |
| Requirements for participation                 | None   |
| Usability of the module                        | Master Courses in the Faculty of Electrical Engineering and Information Technology, and other Master Courses.  |
| Examinations prerequisite                      | Tutorial certificate   |
| Exam performance                               | Written exam 60 minutes at the end of the module   |
| Credit points and grades                       | 3 SWS / 5 CP = 150 h (42 h time of attendance + 108 h autonomous work)<br>Grading scale as per examination regulations   |
| Work effort                                    | Time of attendance: 2 SWS Lecture, 1 SWS Tutorial<br>Autonomous work: Rework of lectures and tutorials, preparation of exercises and exam  |
| Availability                                   | Every year in the winter semester  |
| Duration of the module                         | One Semester   |
| Responsible lecturer                           | Prof. Dr. rer. nat. Georg Rose (FEIT-IMT)  |

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## 2.2.2 Digital Information Processing Laboratory

|  |   |
|--|---|
| English title                                  | Digital Information Processing Laboratory   |
| Qualification goals and contents of the module | <p><b>Learning objectives and acquired competences:</b></p> <ul style="list-style-type: none"> <li>• The participant has an overview of basic methods of applied digital signal processing.</li> <li>• The participant can transform physiological knowledge into technical digital signal processing methods.</li> <li>• Selected Feature Space transformations and their applications are known.</li> <li>• Gaussian Production System Architectures are being estimated under Maximum-Likelihood Assumptions</li> </ul> <p><b>Contents:</b></p> <ul style="list-style-type: none"> <li>• Digital Signals and Digital LTI Systems</li> <li>• Synthesis and analysis of such systems</li> <li>• Selected Digital Filters</li> <li>• Discrete and Fast Fourier Transformations</li> <li>• Selected Feature Space transformations</li> <li>• Gaussian Production System Architectures Characteristics of Human Speech</li> </ul> |
| Literature                                     | <p>[1] Oppenheim, A; Schafer R (2013): "Discrete Time Signal Processing", 1056 pages, Pearson, ISBN: 978-1292025728</p> <p>[2] Lathi, B P; Green, R A (2014) "Essentials of Digital Signal Processing", 748 pages, Cambridge University Press, ISBN: 978-1-107-05932-0</p>  |
| Language                                       | English   |
| Forms of teaching                              | Seminar, Laboratory Internship  |
| Requirements for participation                 | Credits obtained in the module „Digital Information Processing" (Prof. Wendemuth)   |
| Usability of the module                        | Master Courses in the Faculty of Electrical Engineering and Information Technology, and other Master Courses.   |
| Examinations prerequisite                      | Successful laboratory attendance (Praktikumsschein), and grading based on the average of the four best graded laboratory reports.   |
| Exam performance                               | Oral test at the end of the module  |
| Credit points and grades                       | 3 SWS / 5 CP = 150 h (42 h time of attendance + 108 h autonomous work)<br>Grading scale as per examination regulations  |
| Work effort                                    | Time of attendance: 3 SWS Seminar + Laboratory Internship<br>Autonomous work: Pre- and post processing of course, preparation of exam   |
| Availability                                   | Every year in the summer semester   |
| Duration of the module                         | One Semester  |
| Responsible lecturer                           | Prof. Dr. rer. nat. Andreas Wendemuth (FEIT-IIKT)   |

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## 2.2.3 Electronic System Level Modeling

|  |   |
|--|---|
| English title                                  | Electronic System Level Modeling  |
| Qualification goals and contents of the module | <p><b>Learning objectives and acquired competences:</b></p> <p>The increasing complexity of digital systems requires an abstract modeling concept suitable for both software and hardware design. For this purpose, the lecture introduces SystemC and shows how digital systems can be created from abstract system descriptions.</p> <p>After completing the module, students will be able to convert non-formal system descriptions into formal models and transform these into a hardware structure. They can create SystemC models for different levels of abstraction (register transfer level, transaction level) and model temporal processes at different levels (Loosely-Timed, Approximately-Timed). Based on C programs, students can create and optimize data flow models. Furthermore, depending on the problem, the students can determine a suitable approach for the synthesis of circuits and evaluate different synthesis methods.</p> <p>Through practical exercises, students will be able to deepen their knowledge and skills. In doing so, they will create their own system designs in SystemC and analyze their simulation behavior.</p> <p><b>Contents:</b></p> <ul style="list-style-type: none"> <li>• Transaction Level Modeling</li> <li>• Introduction to SystemC</li> <li>• Modeling of temporal processes, timing models</li> <li>• System descriptions</li> <li>• Creation of hardware from C programs</li> <li>• Data flow graphs / system modeling</li> <li>• Basic methods for circuit synthesis</li> </ul> |
| Literature                                     |   |
| Language                                       | English   |
| Forms of teaching                              | Lecture, Exercise   |
| Requirements for participation                 | Bachelor in electrical engineering or computer science, basic knowledge in C and C++  |
| Usability of the module                        | Master Courses in the Faculty of Electrical Engineering and Information Technology, and other Master Courses.   |
| Examinations prerequisite                      | None  |
| Exam performance                               | Oral test at the end of the module  |
| Credit points and grades                       | 3 SWS / 5 CP = 150 h (42 h time of attendance + 108 h autonomous work)<br>Grading scale as per examination regulations  |
| Work effort                                    | Time of attendance: 2 SWS Lecture, 1 SWS Exercise<br>Autonomous work: Post processing of lectures, solving of exercises and preparation of exam   |
| Availability                                   | Every year in the winter semester   |
| Duration of the module                         | One Semester  |
| Responsible lecturer                           | Prof. Dr.-Ing. Thilo Pionteck (FEIT-IKT)  |

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## 2.2.4 FPGA and Microcontroller Programming 1 and 2

|  |  |
|--|--|
| English title                                  | FPGA and Microcontroller Programming 1 and 2   |
| Qualification goals and contents of the module | <p><b>Learning objectives and acquired competences:</b><br/>The student will</p> <ul style="list-style-type: none"> <li>• have an overview about the design process of FPGAs and Microcontrollers Contents.</li> <li>• Programmable logic devices: overview, circuit design of special function blocks, introduction in the hardware description languages and their realization.</li> <li>• Microcontroller: overview, description of special function blocks from the view of circuit design, realization of projects in assembly language and C.</li> <li>• simulation and methods of debugging.</li> </ul> |
| Literature                                     | Documentation available: <a href="http://www.xilinx.com">www.xilinx.com</a>  |
| Language                                       | English  |
| Forms of teaching                              | Laboratory Internship  |
| Requirements for participation                 | Bachelor in Electrical Engineering or related studies, Electronic Circuits   |
| Usability of the module                        | Compulsory elective module in the Master Course "Electrical Engineering and Information Technology".   |
| Examinations prerequisite                      | None   |
| Exam performance                               | Oral test at the end of the module   |
| Credit points and grades                       | 5 SWS / 5 CP = 150 h (70 h time of attendance + 80 h autonomous work)<br>Grading scale as per examination regulations  |
| Work effort                                    | Time of attendance in summer semester: 2 SWS Laboratory Internship<br>Time of attendance in winter semester: 3 SWS Laboratory Internship<br>Autonomous work: Post processing, preparation of laboratory work, research report and exam   |
| Availability                                   | Every year Start in the summer semester  |
| Duration of the module                         | Two Semesters  |
| Responsible lecturer                           | Dipl.-Ing. Helmut Bresch (FEIT IIKT)   |

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## 2.2.5 Heterogeneous Computing

|  |  |
|--|--|
| English title                                  | Heterogeneous Computing  |
| Qualification goals and contents of the module | <p><b>Learning objectives and acquired competences:</b><br/>           After successfully completing the module, students will be able to discuss the computing principles of different hardware platforms and select a suitable computing principle for a given application. They can create applications that can be implemented on different hardware platforms and exploit their individual properties. Students can also transform algorithms in such a way that they make optimal use of the possibilities of a given hardware. The students can analyze the data flow within neural networks and adapt hardware architectures to their specifics. Through theoretical and practical exercises, students will be able to deepen their knowledge and skills in a research-oriented manner. Students will realize algorithms in OpenCL for GPUs and CPUs as well as gain practical experience in creating data flow descriptions for FPGA hardware accelerators.</p> <p><b>Contents:</b></p> <ul style="list-style-type: none"> <li>• Alternative computing principles</li> <li>• Design of hybrid computing systems</li> <li>• Dataflow computing</li> <li>• Introduction to OpenCL</li> <li>• Hardware based OpenCL programming for GPUs, FPGAs, and CPUs</li> <li>• Hardware architecture of GPUs</li> <li>• Introduction to Deep Neural Networks (DNN)</li> <li>• Hardware accelerators for DNNs</li> <li>• Hardware architecture of TPUs</li> </ul> |
| Literature                                     |  |
| Language                                       | English  |
| Forms of teaching                              | Lecture, Exercise  |
| Requirements for participation                 | Bachelor in electrical engineering or computer science, basic knowledge in C and C++   |
| Usability of the module                        | Master Courses in the Faculty of Electrical Engineering and Information Technology, and other Master Courses.  |
| Examinations prerequisite                      | None   |
| Exam performance                               | Oral test at the end of the module   |
| Credit points and grades                       | 3 SWS / 5 CP = 150 h (42 h time of attendance + 108 h autonomous work)<br>Grading scale as per examination regulations   |
| Work effort                                    | Time of attendance: 2 SWS Lecture, 1 SWS Exercise<br>Autonomous work: Post processing of lectures, solving of exercises and preparation of exam  |
| Availability                                   | Every year in the summer semester  |
| Duration of the module                         | One Semester   |
| Responsible lecturer                           | Prof. Dr.-Ing. Thilo Pionteck (FEIT-IKT)   |

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## 2.2.6 Image Coding

|  |   |
|--|---|
| English title                                  | Image Coding  |
| Qualification goals and contents of the module | <p><b>Learning objectives and acquired competences:</b><br/>Learn about methods and techniques of image coding as essential part of image communication. Problems of image acquisition are treated as far as they are relevant for image coding.</p> <p><b>Contents:</b></p> <ul style="list-style-type: none"> <li>● Fundamentals</li> <li>● Basics of human perception</li> <li>● TV Systems</li> <li>● Basics of information</li> <li>● Quantisation</li> <li>● Lossless Coding</li> <li>● Lossy Coding</li> <li>● DPCM</li> <li>● Interframe Prediction</li> <li>● Transform Coding</li> <li>● Content based and semantic Coding</li> <li>● Standards and applications</li> </ul> |
| Literature                                     | [1] John W. Woods: Multidimensional signal, image, and video processing and coding, Academic Press, 2012  |
| Language                                       | English   |
| Forms of teaching                              | Lecture, Exercise   |
| Requirements for participation                 | Bachelor in Electrical Engineering or related studies   |
| Usability of the module                        | Compulsory elective module for the Master Course "Electrical Engineering and Information Technology".   |
| Examinations prerequisite                      | None  |
| Exam performance                               | Oral test at the end of the module  |
| Credit points and grades                       | 3 SWS / 5 CP = 150 h (42 h time of attendance + 108 h autonomous work)<br>Grading scale as per examination regulations  |
| Work effort                                    | Time of attendance: 2 SWS Lecture, 1 SWS Exercise<br>Autonomous work: Post processing of lectures, solving of exercises, preparation of presentation and exam   |
| Availability                                   | Every year in the winter semester   |
| Duration of the module                         | One Semester  |
| Responsible lecturer                           | Dr.-Ing. Gerald Krell (FEIT-IIKT)   |

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## 2.2.7 Introduction to RF Communication Systems

|  |  |
|--|--|
| English title                                  | Introduction to RF Communication Systems   |
| Qualification goals and contents of the module | <p><b>Learning objectives and acquired competences:</b><br/>The student will</p> <ul style="list-style-type: none"> <li>• understand the differences between low-frequency and radio-frequency networks.</li> <li>• gain knowledge about radio-frequency communication systems.</li> <li>• be capable of analyzing and designing selected components of radio-frequency communication systems.</li> </ul> <p><b>Contents:</b></p> <ul style="list-style-type: none"> <li>• Introduction</li> <li>• Transmission lines</li> <li>• Scattering parameters</li> <li>• Matching networks and filters</li> <li>• Attenuators, phase shifters, directional couplers, and circulators</li> <li>• Microwave amplifiers and oscillators</li> </ul> |
| Literature                                     | [1] R.E. Collin, "Foundations for Microwave Engineering", McGraw-Hill, 1966  |
| Language                                       | English  |
| Forms of teaching                              | Lecture, Exercise  |
| Requirements for participation                 | Bachelor in Electrical Engineering or related studies  |
| Usability of the module                        | Master Courses in the Faculty of Electrical Engineering and Information Technology, and other Master Courses.  |
| Examinations prerequisite                      | None   |
| Exam performance                               | Written exam 90 minutes at the end of the module   |
| Credit points and grades                       | 3 SWS / 5 CP = 150 h (42 h time of attendance + 108 h autonomous work)<br>Grading scale as per examination regulations   |
| Work effort                                    | Time of attendance: 2 SWS Lecture, 1 SWS Exercise<br>Autonomous work: Post processing of lectures, solving of exercises, research report and preparation of exam   |
| Availability                                   | Every year in the summer semester  |
| Duration of the module                         | One Semester   |
| Responsible lecturer                           | Prof. Dr.-Ing. habil. Holger Maune (FEIT-IIKT)   |

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## 2.2.8 Microwave Measurement Techniques ( $\mu$ WMT) / Mikrowellenmesstechnik

|  |   |
|--|---|
| English title                                  | Microwave Measurement Techniques ( $\mu$ WMT)   |
| Qualification goals and contents of the module | <p><b>Learning objectives and acquired competences:</b><br/>Students should understand the principles of microwave metrology and be able to be able to apply them independently to measurement problems in the framework of communications and medical engineering. The following Fine Learning Objectives are associated with the lecture:</p> <ul style="list-style-type: none"> <li>• Students will understand the basic principles of power measurement and effects of mismatch or pulsed signals and can independently perform and interpret measurements.</li> <li>• Students will understand the fundamentals of spectrum analysis and will be able to perform and interpret measurements independently.</li> <li>• Students understand the fundamentals of scattering parameter measurement and calibration of network analyzers and are able to perform and interpret perform and interpret measurements.</li> <li>• The students know different methods for material characterization</li> <li>• The students work can solve measurements task such as characterization of biomedical materials or matching of MRI coils.</li> </ul> <p><b>Contents:</b><br/>Introduction to measurement techniques, high frequency components and their characteristics, RF power measurement, spectrum analysis, vector network analysis (scattering parameter, X-parameters, calibration), on-wafer metrology, load/source pull, high frequency characterization of materials.</p> |
| Literature                                     | Lecture notes, further literature is listed in the lecture notes  |
| Language                                       | English   |
| Forms of teaching                              | Lecture, Exercise, Practical Exercise   |
| Language                                       | English or German   |
| Requirements for participation                 | Recommended: Fundamentals of Communication Technology, Fundamentals of High Frequency Technology (previously: High Frequency Technology I)  |
| Usability of the module                        | Compulsory elective module in the master's degree programs as well as other courses of study at FEIT.   |
| Examinations prerequisite                      | None  |
| Exam performance                               | Oral test at the end of the module  |
| Credit points and grades                       | 4 SWS / 6 CP = 180 h (56 h time of attendance + 124 h autonomous work)<br>Grading scale as per examination regulations  |
| Work effort                                    | Time of attendance: 2 SWS Lecture, 1 SWS Exercise, 1 SWS Practical Exercise<br>Autonomous work: Preparation and wrap-up of the lecture, the exercises, and preparation for exams  |
| Availability                                   | Every year in the winter semester   |
| Duration of the module                         | One Semester  |
| Responsible lecturer                           | Prof. Dr. habil. Holger Maune (FEIT-IKT)  |

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## 2.2.9 Seminar „System-on-Chip“

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|--|--|
| English title                                  | Seminar „System-on-Chip“   |
| Qualification goals and contents of the module | <p><b>Learning objectives and acquired competences:</b></p> <p>A system-on-chip (SoC) combines all aspects of a system on a single chip. It is a central component of many mobile computing devices as well as of modern embedded systems. Consequently, the design of SoCs poses many interesting questions, such as the management of heterogeneous processing units, the communication through an on-chip network or the application in critical systems. In this seminar the students work collaboratively to acquire an overview of the state of the art for one of these topics.</p> <p>Through this seminar the students will be able to independently search, understand and classify scientific literature. They will be able to present the acquired knowledge in a systematic way. Furthermore, they get a profound insight on current research topics in the field of system-on-chips.</p> <p><b>Contents:</b></p> <ul style="list-style-type: none"> <li>• Overview of a selected research topic connected to SoCs</li> <li>• How to read scientific papers</li> <li>• How to do a systematic literature search</li> <li>• Developing research questions based on the current state of the art</li> </ul> |
| Literature                                     |  |
| Language                                       | English  |
| Forms of teaching                              | Seminar  |
| Requirements for participation                 | Participation in the lecture “System on Chip” is recommended.  |
| Usability of the module                        | Compulsory elective module in the option “Information and Communication Technology” of the master’s programs of the FEIT and further courses of studies at OvGU.   |
| Examinations prerequisite                      | Active on-site participation in the seminar  |
| Exam performance                               | Presentation   |
| Credit points and grades                       | 3 SWS / 5 CP = 150 h (42 h time of attendance + 108 h autonomous work)<br>Grading scale as per examination regulations   |
| Work effort                                    | Time of attendance: 3 SWS Seminar<br>Autonomous work: Reading assignments, preparation of talks  |
| Availability                                   | Every year in the winter semester  |
| Duration of the module                         | One Semester   |
| Responsible lecturer                           | Prof. Dr.-Ing. Thilo Pionteck (FEIT-IKT)   |

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## 2.2.10 Speech Recognition

|  |   |
|--|---|
| English title                                  | Speech Recognition  |
| Qualification goals and contents of the module | <p><b>Learning objectives and acquired competences:</b></p> <ul style="list-style-type: none"> <li>• The participant understands basic problems and methods of automatic speech recognition with Hidden Markov Models.</li> <li>• The participant understands the functionality of the relevant computer modules in speech recognition and can mathematically explain the modus of operation.</li> <li>• The participant knows specific requirements for speech recognition. These can include reliability, availability, speaker verification.</li> <li>• The participant knows specific requirements and differences in command, dictation and dialogue mode, particularly in the field of applications (e.g. medical) and support systems.</li> </ul> <p><b>Contents:</b></p> <ul style="list-style-type: none"> <li>• Production and Reception of Natural Speech</li> <li>• Feature Extraction</li> <li>• Classification Techniques</li> <li>• Hidden Markov Models (DTW, Viterbi, Baum-Welch)</li> <li>• Language Models</li> <li>• Aspects of robust Speech Recognition: adaptivity, reliability, availability, speaker verification.</li> <li>• Practical Speech Recognition Systems Design</li> </ul> |
| Literature                                     | [1] Rabiner, L & Juang, B (1993): „Fundamentals of Speech Recognition“, 507 pages, Prentice Hall, ISBN: 0-13-015157-2   |
| Language                                       | English   |
| Forms of teaching                              | Lecture, Exercise, Laboratory Internship  |
| Requirements for participation                 | Bachelor in Electrical Engineering or related studies<br>Knowledge of Digital Signal Processing   |
| Usability of the module                        | Compulsory elective module for the Master Course “Electrical Engineering and Information Technology”.   |
| Examinations prerequisite                      | Mandatory participation in exercise classes, successful results in exercises  |
| Exam performance                               | Written exam 90 minutes at the end of the module  |
| Credit points and grades                       | 4 SWS / 5 CP = 150 h (56 h time of attendance + 94 h autonomous work)<br>Grading scale as per examination regulations   |
| Work effort                                    | Time of attendance: 2 SWS Lecture, 1 SWS Exercise, 1 SWS Laboratory Internship<br>Autonomous work: Post processing of lectures, preparation of exercises and exam   |
| Availability                                   | Every year in the summer semester   |
| Duration of the module                         | One Semester  |
| Responsible lecturer                           | Prof. Dr. rer. nat. Andreas Wendemuth (FEIT-IIKT)   |

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## 2.2.11 System-on-Chip

|  |   |
|--|---|
| English title                                  | System-on-Chip  |
| Qualification goals and contents of the module | <p><b>Learning objectives and acquired competences:</b><br/> A system-on-chip (SoC) combines all components of an electronic system on a single chip. This module deals with the basic structure of SoCs, the hardware architecture of the individual components and the effects of design decisions on the chip design. One focus of the lecture is on the design of the internal communication networker. After successful completion of the module, students will be able to independently define the basic structure of application-specific SoCs and to identify and evaluate design alternatives. Students will be able to describe standards and criteria for the design and use of SoCs and place them in the overall context. They can model problems and carry out a systematic design space exploration. They are able to select and parameterize suitable optimization methods. Through theoretical and practical exercises, students are able to deepen their knowledge and skills in a research-oriented manner. The characteristics of different communication architectures are clarified with the help of simulation tools.</p> <p><b>Contents:</b></p> <ul style="list-style-type: none"> <li>• Structure of system-on-chips (SoCs)</li> <li>• ARM processors</li> <li>• Bus architectures and bus standards</li> <li>• Network-on-chips (NoCs)</li> <li>• (heterogeneous) 3D chips</li> <li>• design space exploration</li> <li>• optimization techniques</li> </ul> |
| Literature                                     |   |
| Language                                       | English   |
| Forms of teaching                              | Lecture, Exercise   |
| Requirements for participation                 | Bachelor in electrical engineering or computer science, basic knowledge in C and C++  |
| Usability of the module                        | Compulsory elective module in the Master Course "Electrical Engineering and Information Technology". Compulsory module in other master's degree programs at FEIT.   |
| Examinations prerequisite                      | None  |
| Exam performance                               | Oral test at the end of the module  |
| Credit points and grades                       | 3 SWS / 5 CP = 150 h (42 h time of attendance + 108 h autonomous work)<br>Grading scale as per examination regulations  |
| Work effort                                    | Time of attendance: 2 SWS Lecture, 1 SWS Exercise<br>Autonomous work: Post processing of lectures, solving of exercises and preparation of exam   |
| Availability                                   | Every year in the winter semester   |
| Duration of the module                         | One Semester  |
| Responsible lecturer                           | Prof. Dr.-Ing. Thilo Pionteck (FEIT-IKT)  |

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## 2.2.12 Theoretical Neuroscience II

|  |  |
|--|--|
| English rule                                   | Theoretical Neuroscience II  |
| Qualification goals and contents of the module | <p><b>Learning objectives and acquired competences:</b><br/>Based on Chapters 7-10 of Dayan und Abbott. Rate models of network dynamics, synaptic plasticity, reinforcement learning, and generative models. Linear models of neural networks, dynamic analysis of state-space, eigenvalue analysis of steady-states, models of activity-dependent plasticity, associative learning with neural networks, modern theories of reinforcement learning (Rescorla-Wagner, temporal-difference, actor-critic models), and abstract approaches to representational learning and generative models (expectation maximization, principal components, independent components).</p> <p>To develop a deeper understanding and to acquire applied and practical skills, students perform weekly homework assignments with Matlab programming. A passing grade on all assignments is required for admission to the final exam.</p> <p>The tutorial is open to all students and provides an opportunity for more extensive questions and discussions of the lecture material. It is particularly recommended for students with a weaker background in mathematics and physics.</p> |
| Literature                                     | [1] Dayan and Abbott (2001) Theoretical Neuroscience, MIT Press  |
| Language                                       | English  |
| Forms of teaching                              | Lecture, Exercise  |
| Requirements for participation                 | Required: basic knowledge in Calculus and Linear Algebra<br>Useful: basic knowledge in programming   |
| Usability of the module                        | Master Courses in the Faculty of Electrical Engineering and Information Technology, and other Master Courses.  |
| Examinations prerequisite                      | None   |
| Exam performance                               | Oral test at the end of the module   |
| Credit points and grades                       | 5 SWS / 5 CP = 150 h (70 h time of attendance + 80 h autonomous work)<br>Grading scale as per examination regulations  |
| Work effort                                    | Time of attendance: 3 SWS Lecture, 2 SWS Exercise<br>Autonomous work: Post processing of lectures, solving of exercises, project work and preparation of exam  |
| Availability                                   | Every year in the summer semester  |
| Duration of the module                         | One Semester   |
| Responsible lecturer                           | Prof. Dr. Jochen Braun (FNW-IBIO)  |

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## 2.3 Field of Study Microsystems

The option "Microsystems" is not offered at the moment.

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## 2.4 Field of Study Power and Energy

### 2.4.1 Control of AC Drives (Regelung von Drehstrommaschinen)

|  |  |
|--|--|
| English title                                  | Control of AC Drives   |
| Qualification goals and contents of the module | <p><b>Learning objectives and acquired competences:</b><br/>The students will get knowledge about the dynamic models of the usual AC electric machines and the space vector representation. They will be able to understand the algorithms for the control of AC drives and to adjust their parameters. They will also be capable to assess advantages and drawback of the different machine types and control algorithms depending on a given application.</p> <p><b>Contents:</b></p> <ul style="list-style-type: none"><li>• Optimization of control loops</li><li>• The inverter as a power electronic actuator</li><li>• Space vector representation</li><li>• Model of the permanent magnet synchronous machine (PMSM)</li><li>• Field oriented control of the PMSM</li><li>• Model of the Induction machine (IM)</li><li>• Field oriented control of the IM</li><li>• Direct torque control (DTC)</li></ul> |
| Literature                                     | <p>[1] De Doncker et.al.: Advanced Electrical Drives, Analysis, Modeling, Control. Springer Science+Business Media B.V. 2011</p> <p>[2] Mukhtar Ahmad: High Performance AC Drives, Modelling Analysis and Control. Springer-Verlag 2010</p>  |
| Language                                       | English  |
| Forms of teaching                              | Lecture, Exercise  |
| Requirements for participation                 | Knowledge of Control Systems and Power Electronics   |
| Usability of the module                        | Compulsory module for the Master Courses ETIT-EE and EE-RE.<br>Compulsory elective module for the Master Courses EEIT, ETIT, MTK and STK.  |
| Examinations prerequisite                      | None   |
| Exam performance                               | Written exam 90 minutes at the end of the module   |
| Credit points and grades                       | 3 SWS / 5 CP = 150 h (42 h time of attendance + 108 h autonomous work)<br>Grading scale as per examination regulations   |
| Work effort                                    | Time of attendance: 2 SWS Lecture, 1 SWS Exercise<br>Autonomous work: Post processing of lectures, preparation of project report and exam  |
| Availability                                   | Every year in the winter semester  |
| Duration of the module                         | One Semester   |
| Responsible lecturer                           | Prof. Dr.-Ing. Roberto Leidhold (FEIT-IESY)  |

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## 2.4.2 Digital Protection of Power Networks

|  |  |
|--|--|
| English title                                  | Digital Protection of Power Networks   |
| Qualification goals and contents of the module | <p><b>Learning objectives and acquired competences:</b><br/>The students will get acquainted with the knowledge about power system protection concepts as well as related digital signal processing algorithms. The students will be able to use appropriate means as well as prepare settings of protection for any network elements and structures.</p> <p><b>Contents:</b></p> <ul style="list-style-type: none"> <li>• Concepts and requirements of power system protection</li> <li>• Protection of particular network elements <ul style="list-style-type: none"> <li>○ power lines</li> <li>○ transformers</li> <li>○ generators</li> <li>○ busbars</li> </ul> </li> <li>• Digital signal processing for protection purposes <ul style="list-style-type: none"> <li>○ digital filtering</li> <li>○ calculation of protection criteria</li> <li>○ decision-making and logic</li> </ul> </li> <li>• Adaptive and intelligent protection systems <ul style="list-style-type: none"> <li>○ adaptive and multi-criteria systems</li> <li>○ artificial intelligence – based systems</li> </ul> </li> <li>• wide-area protection concepts</li> </ul> |
| Literature                                     |  |
| Language                                       | English  |
| Forms of teaching                              | Lecture, Exercise  |
| Requirements for participation                 | Knowledge of power system basics   |
| Usability of the module                        | Compulsory elective module for the Master Course “Electrical Engineering and Information Technology”.  |
| Examinations prerequisite                      | None   |
| Exam performance                               | Written exam 120 minutes at the end of the module and project report   |
| Credit points and grades                       | 3 SWS / 5 CP = 150 h (42 h time of attendance + 108 h autonomous work)<br>Grading scale as per examination regulations   |
| Work effort                                    | Time of attendance: 2 SWS Lecture, 1 SWS Exercise<br>Autonomous work: Post processing of lectures, preparation of project report and exam  |
| Availability                                   | Every year in the summer semester  |
| Duration of the module                         | One Semester (block-wise at the end of semester)   |
| Responsible lecturer                           | Prof. Dr.-Ing. habil. Waldemar Rebizant (WUST-FEE)   |

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## 2.4.3 Electromagnetic Compatibility (EMC)

|  |  |
|--|--|
| English title                                  | Electromagnetic Compatibility  |
| Qualification goals and contents of the module | <p><b>Learning objectives and acquired competences:</b><br/>The students gain information on the fundamental concepts, principles and measurement techniques of electromagnetic compatibility (EMC). At the end of the module, they are able to understand and apply measures to improve the EMC of electric and electronic systems. They will also be able to analyze the EMC of electrical systems.</p> <p><b>Contents:</b></p> <ul style="list-style-type: none"> <li>• Introduction</li> <li>• EMC regulation</li> <li>• EM coupling, shielding, filtering</li> <li>• EMC analysis</li> <li>• Interference models for special applications</li> <li>• EMC measures in electronic circuits</li> <li>• Measurement techniques</li> </ul> |
| Literature                                     | [1] K.-H. Gonschoreck, R. Vick: Electromagnetic Compatibility for Device Design and System Integration. Springer Verlag  |
| Language                                       | English  |
| Forms of teaching                              | Lecture, Exercise  |
| Requirements for participation                 | Bachelor in Electrical Engineering or related studies  |
| Usability of the module                        | Compulsory elective module for the Master Course “Electrical Engineering and Information Technology” and “Medial System Engineering”.  |
| Examinations prerequisite                      | None   |
| Exam performance                               | Oral test at the end of the module   |
| Credit points and grades                       | 4 SWS / 5 CP = 150 h (56 h time of attendance + 94 h autonomous work)<br>Grading scale as per examination regulations  |
| Work effort                                    | Time of attendance: 2 SWS Lecture, 2 SWS Exercise<br>Autonomous work: Post processing of lectures and laboratory work, preparation of exercises, laboratory work, research report and exam   |
| Availability                                   | Every year in the winter semester  |
| Duration of the module                         | One Semester   |
| Responsible lecturer                           | Prof. Dr.-Ing. Ralf Vick (FEIT-IMT)  |

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## 2.4.4 Power Electronic Components and Systems

|  |   |
|--|---|
| English title                                  | Power Electronic Components and Systems   |
| Qualification goals and contents of the module | <p><b>Learning objectives and acquired competences:</b><br/>           Knowledge about power semiconductor components as part of power supply or drive systems shall be imparted, considering the mutual interaction between component and system level. Applications will be demonstrated in the exercise. To strengthen the competence for interdisciplinary work, consideration of questions of reliability shall show cross-links to related fields of engineering.</p> <p><b>Contents:</b></p> <ul style="list-style-type: none"> <li>● power electronic components               <ul style="list-style-type: none"> <li>○ functionality, ratings and characteristics of IGBT, MOSFET and diode</li> <li>○ packaging and assembly</li> </ul> </li> <li>● power electronic systems               <ul style="list-style-type: none"> <li>○ component stress in selected power supply and drive systems</li> <li>○ dimensioning</li> <li>○ reliability</li> </ul> </li> </ul> |
| Literature                                     | [1] Ned Mohan: Power electronics - converters, applications and design; Wiley, Hoboken NJ, 3rd edition 2003   |
| Language                                       | English   |
| Forms of teaching                              | Lecture, Exercise   |
| Requirements for participation                 | Bachelor in Electrical Engineering or related studies and Master Course "Power Electronics"   |
| Usability of the module                        | Selectable module for the Master Course "Electrical Engineering and Information Technology", belonging to the field of electrical energy systems.   |
| Examinations prerequisite                      | None  |
| Exam performance                               | Oral test at the end of the module  |
| Credit points and grades                       | 3 SWS / 5 CP = 150 h (42 h time of attendance + 108 h autonomous work)<br>Grading scale as per examination regulations  |
| Work effort                                    | Time of attendance: 2 SWS Lecture, 1 SWS Exercise<br>Autonomous work: Post processing of lectures, preparation of exercises and exam  |
| Availability                                   | Every year in the winter semester   |
| Duration of the module                         | One Semester  |
| Responsible lecturer                           | Prof. Dr.-Ing. Andreas Lindemann (FEIT-IESY)  |

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## 2.4.5 Power System Economics and Special Topics

|  |  |
|--|--|
| English title                                  | Power System Economics and Special Topics  |
| Qualification goals and contents of the module | <p><b>Learning objectives and acquired competences:</b><br/>The student will learn</p> <ul style="list-style-type: none"> <li>• the main principles of high voltage and high current engineering.</li> <li>• the principles of materials used as isolator.</li> <li>• how to calculate economics of power systems.</li> <li>• how the energy market is structured and organized.</li> <li>• how to calculate the reliability and ability of power grid components.</li> <li>• how energy trading is organized and power prices will be calculated.</li> </ul> <p><b>Contents:</b></p> <ul style="list-style-type: none"> <li>• Electric power market and its liberalization</li> <li>• Financing account</li> <li>• The costs of transmission</li> <li>• Liberalization of European energy market</li> <li>• Energy trading</li> <li>• Network reliability</li> <li>• Network planning</li> <li>• Computing in network planning</li> <li>• High voltage measurement</li> <li>• High voltage and high current generation</li> <li>• Isolation materials</li> <li>• Isolation technology engineering</li> <li>• Use of high voltage technology in testing</li> </ul> |
| Literature                                     | <p>[1] "Fundamentals of Power System Economics", Daniel S. Kirschen, Goran Strbac, John Wiley &amp; Sons Ltd, 2004</p> <p>[2] "Power System Economics: designing markets for electricity", Steven Stoft. Wiley Interscience, 2002</p>  |
| Language                                       | English  |
| Forms of teaching                              | Lecture, Exercise  |
| Requirements for participation                 | Bachelor in Electrical Engineering or related studies  |
| Usability of the module                        | Compulsory elective module for the Master Course "Electrical Engineering and Information Technology".  |
| Examinations prerequisite                      | None   |
| Exam performance                               | Written exam 90 minutes at the end of the module   |
| Credit points and grades                       | 3 SWS / 5 CP = 150 h (42 h time of attendance + 108 h autonomous work)<br>Grading scale as per examination regulations   |
| Work effort                                    | Time of attendance: 1 SWS Lecture, 2 SWS Exercise<br>Autonomous work: Post processing of lectures, preparation of exercises and exam   |
| Availability                                   | Every year in the winter semester  |
| Duration of the module                         | One Semester   |
| Responsible lecturer                           | Prof. Dr.-Ing. habil. Martin Wolter (FEIT-IESY)  |

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## 2.4.6 Power System Dynamics

|  |   |
|--|---|
| English title                                  | Power System Dynamics   |
| Qualification goals and contents of the module | <p><b>Learning objectives and acquired competences:</b><br/>By completing the module, the students acquire in-depth knowledge of the characteristic transient behavior of electric power systems. Extended modeling and calculation methods are taught that consider the dynamic properties of both the individual equipment and the overall system. The participants will be able to design the required models and to apply them when performing transient simulations of power systems.</p> <p><b>Contents:</b></p> <ul style="list-style-type: none"> <li>● Power system dynamic simulation <ul style="list-style-type: none"> <li>○ Modal components</li> <li>○ State space models</li> <li>○ Extended nodal approach</li> <li>○ differential conductance method</li> </ul> </li> <li>● Dynamic models of equipment <ul style="list-style-type: none"> <li>○ Lines, transformers, generators, motors</li> <li>○ Switching operations</li> </ul> </li> <li>● Dynamic security assessment</li> <li>● Matlab seminar</li> </ul> |
| Literature                                     |   |
| Language                                       | English   |
| Forms of teaching                              | Lecture, Exercise, Matlab Seminar   |
| Requirements for participation                 | Power Network Planning and Operation  |
| Usability of the module                        | Compulsory elective module for the Master Course “Electrical Engineering and Information Technology”, belonging to the field of electrical energy systems.  |
| Examinations prerequisite                      | None  |
| Exam performance                               | Oral test at the end of the module  |
| Credit points and grades                       | 3 SWS / 5 CP = 150 h (42 h time of attendance + 108 h autonomous work)<br>Grading scale as per examination regulations  |
| Work effort                                    | Time of attendance: 2 SWS Lecture, 1 SWS Exercise<br>Autonomous work: Post processing of lectures, solving of exercises, preparation of exercises and exam  |
| Availability                                   | Every year in the summer semester   |
| Duration of the module                         | One Semester  |
| Responsible lecturer                           | Prof. Dr.-Ing. habil. Martin Wolter (FEIT-IESY)   |

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## 2.4.7 Renewable Energy Sources

|  |   |
|--|---|
| English title                                  | Renewable Energy Sources  |
| Qualification goals and contents of the module | <p><b>Learning objectives and acquired competences:</b><br/>The student will learn about energy conversion processes of different types of renewable energy sources, the regulatory framework and the challenges of grid integration. Thereby, wind energy, photovoltaic systems, biomass and fuel cells are focused. Grid integration includes possibilities and limitations of energy storage as well.</p> <p><b>Contents:</b></p> <ul style="list-style-type: none"> <li>• Introduction to Renewable sources</li> <li>• Legal Framework, priority and subsidies</li> <li>• Functionality of energy conversion</li> <li>• Introduction to Fuel Cells</li> <li>• Introduction to energy storage</li> </ul> |
| Literature                                     | <p>[1] "Renewable Energy Systems Fundamentals, Technologies, Techniques and Economics", Z. A. Styczynski, N. I. Voropai (Editors), ISBN: 978-3-940961-42-6, 2010</p> <p>[2] "Power Conversion of Renewable Energy Systems", E. F. Fuchs, Mohammad A. S. Masoum, Springer-Verlag, 2011</p>   |
| Language                                       | English   |
| Forms of teaching                              | Lecture, Exercise   |
| Requirements for participation                 | Bachelor in Electrical Engineering or related studies   |
| Usability of the module                        | Compulsory elective module for the Master Course "Electrical Engineering and Information Technology".   |
| Examinations prerequisite                      | None  |
| Exam performance                               | Written exam 90 minutes at the end of the module  |
| Credit points and grades                       | 3 SWS / 5 CP = 150 h (42 h time of attendance + 108 h autonomous work)<br>Grading scale as per examination regulations  |
| Work effort                                    | Time of attendance: 2 SWS Lecture, 1 SWS Exercise<br>Autonomous work: Post processing of lectures, preparation of exercises and exam  |
| Availability                                   | Every year in the summer semester   |
| Duration of the module                         | One Semester  |
| Responsible lecturer                           | Prof. Dr.-Ing. habil. Martin Wolter (FEIT-IESY)   |

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## 2.5 General

### 2.5.1 Basics of Medical Image Science

|  |  |
|--|--|
| English title                                  | Basics of Medical Image Science  |
| Qualification goals and contents of the module | <b>Learning objectives and acquired competences:</b><br>The Student will: <ul style="list-style-type: none"><li>• get an overview about radiation principles including types of ionizing radiation and their behaviour</li><li>• learn about the difference between active and passive imaging methods and examples from medical imaging techniques</li><li>• get to know system theory of medical imaging systems</li><li>• learn to understand the differences between Fourier-based and task-based image quality descriptions</li><li>• understand how image quality can be described by different types of observers (human and model observers)</li></ul> <b>Contents:</b> <ul style="list-style-type: none"><li>• Radiation physics for alpha-, beta-, gamma-, neutron- and X-ray radiation</li><li>• MTF, NPS and DQE</li><li>• Ideal observer, human observer models, ROC curves</li></ul> |
| Literature                                     | provided by e-learning system  |
| Language                                       | English  |
| Forms of teaching                              | Lecture, Exercise  |
| Requirements for participation                 | Recommended: Mathematics, Physics, Fundamentals in Electrical Engineering  |
| Usability of the module                        | Master program   |
| Examinations prerequisite                      | None   |
| Exam performance                               | Written exam of 90 minutes at the end of the module  |
| Credit points and grades                       | 3 SWS / 5 CP = 150 h (42 h time of attendance + 108 h autonomous work)<br>Grading scale as per examination regulations   |
| Work effort                                    | Time of attendance: 2 SWS Lecture, 1 SWS Exercise<br>Autonomous work: Rework of lectures and exercises, preparation of exercises   |
| Availability                                   | Every summer semester (starting from summer term 2022)   |
| Duration of the module                         | One Semester   |
| Responsible lecturer                           | Prof. Dr. rer. nat. Christoph Hoeschen (FEIT-IMT)  |

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## 2.5.2 Integrated Project

|  |   |
|--|---|
| English title                                  | Integrated Project  |
| Qualification goals and contents of the module | <p><b>Learning objectives and acquired competences:</b><br/>This module serves to improve and apply the knowledge gained in a research-related topic. The student will develop his skills to work on a scientific topic under supervision. He will learn to perform research including accessible literature. In addition, the student will be able to develop his own research project.</p> <p><b>Contents:</b><br/>The content of teaching is largely determined by the research project.</p> |
| Literature                                     |   |
| Language                                       | English   |
| Forms of teaching                              | Scientific project  |
| Requirements for participation                 | Bachelor in Electrical Engineering or related studies   |
| Usability of the module                        | Compulsory elective module for the Master Course "Electrical Engineering and Information Technology".   |
| Examinations prerequisite                      | None  |
| Exam performance                               | Research project (PRO)  |
| Credit points and grades                       | 6 SWS / 10 CP = 300 h (84 h time of attendance + 216 h autonomous work)<br>Grading scale as per examination regulations   |
| Work effort                                    | Time of attendance: 6 SWS Scientific project<br>Autonomous work: Post processing of seminars and tutorials, preparation and performance of scientific work, preparation of presentations and a project  |
| Availability                                   | Every year in the winter semester   |
| Duration of the module                         | One Semester  |
| Responsible lecturer                           | Supervisor of the project   |

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### 2.5.3 Micromechanics

|  |  |
|--|--|
| English Title                                  | Micromechanics   |
| Qualification goals and contents of the module | <p><b>Learning objectives and acquired competences:</b><br/>           Micromechanics is the core that sets apart micro-electromechanical systems (MEMS) from microelectronics. While the laws of physics on the micro scale are the same as on the macro scale, different effects become relevant, resulting in different engineering concepts.</p> <p>After completing this module, the students are aware of the general mechanical engineering concepts of micro-electromechanical systems and the most common structural and functional components. They are further equipped with the understanding and the tools to quickly estimate the mechanical response such as displacements, forces, flow speeds or resonance frequencies either from the response of building blocks that we derive in classes or from first principles. In combination with the application examples, this puts them in the position to find suitable MEMS solutions based on conventional building blocks and to develop new fundamental working principles.</p> <p><b>Content:</b></p> <ol style="list-style-type: none"> <li>1. Introduction, comparison of macro and micro scale</li> <li>2. Solid mechanics               <ul style="list-style-type: none"> <li>• Cantilever springs</li> <li>• Spring systems</li> <li>• Resonances</li> </ul> </li> <li>3. Micro fluidics               <ul style="list-style-type: none"> <li>• Basic fluidic equations, flow profiles, turbulence</li> <li>• Surface tension, capillary effect, droplet generation</li> <li>• Diffusion</li> </ul> </li> <li>4. Micro actuators               <ul style="list-style-type: none"> <li>• Fundamental motivation of principle of least action; Euler-Lagrange equation; principle of virtual work</li> <li>• Electrostatic actuators: Parallel plate, pull-in effect, comb drives, electrowetting, dielectric electroactive polymers; Paschen effect</li> <li>• Magnetic actuators: Lorentz force, voice coil actuators, reluctance actuators</li> <li>• Solid state actuators: Piezo actuators, thermal actuators, bending actuators, 1D and 2D buckling actuators, shape memory materials</li> </ul> </li> <li>5. Application examples               <ul style="list-style-type: none"> <li>• Micro pumps</li> <li>• Adaptive lenses</li> <li>• Smart phone camera</li> <li>• Scanning mirrors</li> </ul> </li> </ol> |
| Literature                                     |  |
| Language                                       | English  |
| Forms of teaching                              | Lecture, Exercise  |
| Requirements for participation                 | Engineering mathematics and physics, e.g., bachelor degree in Electrical Engineering, Mechanical Engineering, Physics or related discipline.   |
| Usability of the module                        | Compulsory elective module in the master's degree program EEIT as well as other master's degree programs of FEIT.  |
| Examinations prerequisite                      | None   |
| Exam performance                               | Written exam 90 minutes at the end of the module   |
| Credit points and grades                       | 3 SWS / 5 CP = 150 h (42 h time of attendance + 108 h autonomous work)<br>Grading scale as per examination regulations   |

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| Work effort           | Time of attendance: 2 SWS Lecture, 1 SWS Exercise<br>Autonomous work: Post processing of lectures, solving and preparation of exercises, preparation of exam |
| Availability          | Every year in the winter semester  |
| Dauer des Moduls      | One Semester   |
| Modulverantwortlicher | Prof. Dr. Matthias Wapler (FEIT-IMT)   |

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# 3 Master Thesis

## 3.1 Master Thesis

|  |   |
|--|---|
| English title                                  | Master Thesis   |
| Qualification goals and contents of the module | <b>Learning objectives and acquired competences:</b><br>Students can work in a research-oriented and scientific manner. They can select and apply suitable scientific methods to solve a defined problem and critically evaluate and classify the results obtained. They can identify information needs, find and obtain information. Students are able to write a research-oriented scientific text to the extent of a Master's thesis. The student is able to present this work and to answer questions scientifically.<br><br><b>Contents:</b><br>after arrangement with the advisor |
| Language                                       | English   |
| Forms of teaching                              | term paper, presentation  |
| Requirements for participation                 | see study and examination regulations   |
| Usability of the module                        | There is no interaction with other modules.   |
| Examinations prerequisite                      | According to the requirements of the study and examination regulations  |
| Exam performance                               | term paper, presentation<br>Submission of a scientific text with novelty character prepared by the participant himself/herself, as part of a Master's thesis as well as the presentation and defence of the thesis.   |
| Credit points and grades                       | 30 CP = 900 h autonomous work<br>Grading scale as per examination regulations   |
| Work effort                                    | After topic-specific agreement with the advisor<br>autonomous work: Research-oriented scientific work   |
| Availability                                   | Every year in the summer semester or winter semester  |
| Duration of the module                         | One Semester  |
| Responsible lecturer                           | Supervisor of the Master Thesis   |

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