Brandenburgische Technische Universität Cottbus - Senftenberg
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Brandenburgische
Technische Universität
Cottbus - Senftenberg

Modulhandbuch für den Studiengang Micro- and Nanoelectronics (universitäres Profil), Master of Science, Prüfungsordnung 2024

Inhaltsverzeichnis

Module 14025 Master Thesis

assign to: Total Account

Study programme Micro- and Nanoelectronics

Degree	Module Number	Module Form
Master of Science	14025	Mandatory

Modul Title	**Master Thesis** Master-Arbeit
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr. rer. nat. habil. Fischer, Inga Anita
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every semester
Credits	30
Learning Outcome	After successfully completing the module, students understand and can elaborate on problems from modern research under the guidance of their supervisor. Furthermore, they apply their individual abilities as self-efficacy, team work and communication, time management and persistence.
Contents	Elaboration of the subject of the Master Thesis. Written presentation of the results in a scientific accepted form. Elaboration of an oral presentation on the project of the thesis.
Recommended Prerequisites	none
Mandatory Prerequisites	• At least 84 credit points • Passing the module examination of module 14026 *Research Module*
Forms of Teaching and Proportion	Research paper/essay - 900 hours
Teaching Materials and Literature	Literature from the scientific field of the master thesis
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• written master thesis, scheduled working time: five month (75%) • oral presentation (30 minutes), with subsequent discussion, with grade, (25%)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none

Remarks	• Study programme Micro- and Nanoelectronics M.Sc.: Mandatory module The period up to the submission of the written elaboration is 5 months (study regulations §8). After approval by the examination board, the Master's thesis can be written in German in exceptional cases (PStO §8).
Module Components	• Consultations, according to agreement • Oral presentation (colloquium)
Components to be offered in the Current Semester	No assignment

Module 14026 Research Module

assign to: Total Account

Study programme Micro- and Nanoelectronics

Degree	Module Number	Module Form
Master of Science	14026	Compulsory elective

Modul Title	**Research Module** Forschungs-Projekt
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr.-Ing. Rudolph, Matthias
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every semester
Credits	12
Learning Outcome	After successfully completing the module, students have the ability to familiarize themselves with the diverse application- and research-related fields of expertise relevant to micro- and nanoelectronics, and to deal with the frequently changing tasks that they will encounter in their subsequent professional lives. They are able to work in a team, have individual skills such as diligence, perseverance, time management and initiative and can hold a technical discussion.
Contents	The research module consists of a project planning phase as well as a laboratory internship and concludes with a seminar talk. It is usually carried out in the same subject area in which the master's thesis is to be written. Under the guidance of a supervisor, the students deal with a scientific question in a selected research field. The supervisor is a university lecturer at the BTU or a scientist at a non-university institute. In the second case, the course director names a mentor from the electrical engineering department or the physics department at the beginning of the module, who will be involved in the assessment.
Recommended Prerequisites	none
Mandatory Prerequisites	• At least 42 credit points
Forms of Teaching and Proportion	Study project - 240 hours Self organised studies - 120 hours
Teaching Materials and Literature	References will be provided by the supervisor.
Module Examination	Continuous Assessment (MCA)

Assessment Mode for Module Examination	• Oral presentation, approx. 30 minutes (90%) • Written report, approx 20 pages (10%)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	• Study programme Micro- and Nanoelectronics M.Sc.: Mandatory module
Module Components	• Working group Seminars, by arrangement
Components to be offered in the Current Semester	No assignment

Module 14031 Physics of Modern Devices

assign to: Basics

Study programme Micro- and Nanoelectronics

Degree	Module Number	Module Form
Master of Science	14031	Compulsory elective

Modul Title	**Physics of Modern Devices** Physik moderner Bauelemente
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr. rer. nat. habil. Fischer, Inga Anita
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	After successfully completing the module, students are acquainted with concepts of quantum mechanics and solid state physics and their application to the description of modern devices as well as their relevance for nanoscience, nanotechnology and information technology using real-world examples. They not only know how to acquire scientific knowledge but are also able to place physical phenomena into a more general context while exploring links between the different topics. In addition, students possess personal skills such as the capability for teamwork, precise reasoning, perseverance and openmindedness.
Contents	• Quantum mechanics - fundamental concepts relevant to the description of modern devices • Solid state physics - fundamental concepts relevant to the description of modern devices • Band structure calculations: Graphene • Effective mass theory and tunneling currents in semiconductor devices • Application examples (Flash memory, tunnel diodes, quantum effects in MOSFETs, ...)
Recommended Prerequisites	Knowledge of physics at a level corresponding to the first four semesters of a Bachelor’s degree in physics or corresponding to the level of a Bachelor’s degree in electrical engineering.
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester

	Exercise - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	• A. F. J. Levi, Applied Quantum Mechanics Will be added during the first lecture: scientific publications.
Module Examination	Final Module Examination (MAP)
Assessment Mode for Module Examination	• Written exam, 90 minutes
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	• Study programme Physik B.Sc.: Compulsory elective module in complex „Physikalisches Vertiefungsfach“ • Study programme Physics M.Sc.: Compulsory elective module in complex „Physical Specialization with Experimental Focus“, topic area „Nanophysics“ • Study programme Micro- and Nanoelectronics M.Sc.: Mandatory module for students without a Bachelor's degree in physics • Study programme Micro- and Nanoelectronics M.Sc.: Compulsory elective module in complex „Technology and Devices“ (if no mandatory module)
Module Components	• Lecture: Physics of Modern Devices • Accompanying exercise • Related examination
Components to be offered in the Current Semester	**152260** Lecture Physics of Modern Devices - 2 Hours per Term **152261** Exercise Physics of Modern Devices - 2 Hours per Term **152262** Examination Physics of Modern Devices

Module 14032 Introduction to Microwave Electronics

assign to: Basics

Study programme Micro- and Nanoelectronics

Degree	Module Number	Module Form
Master of Science	14032	Compulsory elective

Modul Title	**Introduction to Microwave Electronics** Einführung in die Mikrowellenelektronik
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr.-Ing. Rudolph, Matthias
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	After successfully completing the module, students are acquainted with basic principles of microwave electronics. They not only know how to acquire scientific knowledge but are also able to exploit their knowledge of individual physical phenomena to develop technical solutions in a systematic engineering way.
Contents	• Bipolar and field-effect transistor physics and operation • Basic electronic concepts • Transmission-line theory • Linear multiport theory • Electronic noise
Recommended Prerequisites	Knowledge of topics of physics and electrical engineering at a level corresponding to the first four semesters of a Bachelor’s degree in electrical engineering or corresponding to the level of a Bachelor’s degree in physics
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 3 hours per week per semester Exercise - 2 hours per week per semester Self organised studies - 105 hours
Teaching Materials and Literature	• H. L. Hartnagel, R. Quay, U. L. Rohde, and M. Rudolph, Eds., Fundamentals of RF and Microwave Techniques and Technologies. Cham: Springer International Publishing, 2023. doi: 10.1007/978-3-030-94100-0

- Ulrich Tietze, Christoph Schenk, Eberhard Gamm, Electronic Circuits - Handbook for Design and Application, Springer-Verlag Berlin Heidelberg 2008, doi.org/10.1007/978-3-540-78655-9
- G. D. Vendelin, A. M. Pavio, U. L. Rohde, and M. Rudolph, Microwave circuit design: using linear and nonlinear techniques, Third edition. Hoboken, N.J., USA: Wiley, 2021.
- U. L. Rohde and M. Rudolph, RF / Microwave /Circuit Design for Wireless Applications/. John Wiley & Sons, 2013.

Module Examination	Final Module Examination (MAP)
Assessment Mode for Module Examination	• Written exam, 90 min.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	• Study programme Micro- and Nanoelectronics M.Sc.: Mandatory module for students without a Bachelor's degree in electrical engineering • Study programme Micro- and Nanoelectronics M.Sc.: Compulsory elective module in complex „Circuit Design“ (if no mandatory module)
Module Components	• Lecture: Introduction to Microwave Electronics • Accompanying exercise • Related examination
Components to be offered in the Current Semester	**112130** Lecture Introduction to Microwave Electronic - 3 Hours per Term **112131** Exercise Introduction to Microwave Electronic: - 2 Hours per Term **112132** Examination Introduction to Microwave Electronic:

Module 11221 Fundamentals in Power Electronics

assign to: Technology and Devices

Study programme Micro- and Nanoelectronics

Degree	Module Number	Module Form
Master of Science	11221	Compulsory elective

Modul Title	**Fundamentals in Power Electronics** Grundlagen der Leistungselektronik
Department	Faculty 3 - Mechanical Engineering, Electrical and Energy Systems
Responsible Staff Member	Prof. Dr.-Ing. Möhlenkamp, Georg
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	Students learn to understand the functional principle of power electronics, their specific components, control structures and the characteristic behaviour. They are able to find suitable concepts and define components and auxiliaries for power converters.
Contents	• Definition of power electronics • Components and their static and transient behaviour • Circuit topologies as grid commutated converter • Self commutated converter • Dc-dc-converter • Resonant and quasi-resonant converter • Single and three phase applications • Characteristic values of components and topologies • Cooling • Passive components and filters • Firing • Driver and protection devices • Pulse-width-modulation • Simulation tools
Recommended Prerequisites	Fundamentals in electrical engineering
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Seminar - 1 hours per week per semester Practical training - 1 hours per week per semester Self organised studies - 120 hours

Teaching Materials and Literature	will be given in lecture
Module Examination	Prerequisite + Final Module Examination (MAP)
Assessment Mode for Module Examination	**Prerequisite:** • Successful completion of the laboratory work **Final Module Examination:** • Written examination, 90 minutes
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	The seminar contains a mixture of exercises, laboratory tests and homework.
Module Components	• Fundamenatls in Power Electronics (lecture/seminar/laboratory)
Components to be offered in the Current Semester	**320552** Practical training Fundamentals in Power Electronics - 1 Hours per Term **320551** Lecture/Seminar Fundamentals in Power Electronics - 3 Hours per Term **320576** Examination Fundamentals in Power Electronics

Module 13009 Semiconductor Technology

assign to: Technology and Devices

Study programme Micro- and Nanoelectronics

Degree	Module Number	Module Form
Master of Science	13009	Compulsory elective

Modul Title	**Semiconductor Technology** Halbleitertechnologie
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr.-Ing. Kahmen, Gerhard
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	After successfully completing the module, students have learned the fundamentals of semiconductor physics, the topology and functionality of key semiconductor devices and seminconductor munufacturing processes to realize integrated silicon-based circuits. They have gained an insight into the adjacent fields of material and device diagnostics, manufacturing process control and an overview of technological trends in the semiconductor industry. The knowledge gained from this course enables the students to evaluate given semiconductor technologies with regard to their suitability for apllication, e.g. in electronic circuits and systems.
Contents	• Historical overview of the development of semiconductor technology and semiconductor market • Semiconductor physics basics • Basics of integrated semiconductor devices (passives, diode, bipolartransistor, FET) • Si crystal lattice, crystal growth, wafer production, doping and contamination of wafer material • Oxidation • Doping by diffusion and implantation • Layer deposition and Epitaxial growth of crystalline Si(Ge) layers on the substrate • Structuring by lithography, etching process • Cleaning and planarization processes • Silicon on insulator (SOI) • Diagnostics, process control & Metrology for Si-based semiconductor processes

	• Outlook on future semiconductor technologies • Excursion to visit semiconductor FAB at IHP-Leibniz Institute for High Performance Microelectronics
Recommended Prerequisites	• Knowledge of semiconductor physics based on the bachelor degree in physics, in particular knowledge of the content of module 11868: Allgemeine Physik IV (Festkörperphysik) • Knowledge of the functioning and structure of electronic components, such as knowledge of the content of module 12364: Elektronische Bauelemente und Grundschaltungen • Knowledge of solid-state physics or electrical engineering at a level corresponding to the first four semesters of a Bachelor's degree in physics or electrical engineering
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Study project - 30 hours Self organised studies - 120 hours
Teaching Materials and Literature	Teaching material will be provided before each lecture Recommended Literature: • S.M. Sze, „Physics of Semiconductor Devices“, John Wiley & Sons, 3rd Edition, 2008 • R. Doering, Y. Nishi, “Handbook of Semiconductor Manufacturing Technology”, CRC Press, 2nd Edition, 2008 • P.R. Gray, P.J. Hurst, S.H. Lewis, R.G. Meyer, „Analysis and Design of Analog Integrated Circuits“, John Whiley & Sons, 4th Edition, 2001 • S. Dimirijev, „Understanding Semiconductor Devices“, Oxford University Press, 2nd Edition • J.D. Cressler, G. Niu, „Silicon-Germanium Heterojunction Bipolar Transistors“, Artech House, 2003 • D. A. Neamen, „Semiconductor Physics and Devices“, Mc Graw Hill, Fourth Edition, 2012
Module Examination	Prerequisite + Final Module Examination (MAP)
Assessment Mode for Module Examination	**Prerequisite:** • Successful elaboration and presentation of Homework / Study, 10-15 min. **Final module examination:** • Oral examination, 45 min. OR • Written examination, 120 min. (for large numbers of participants) In the first lecture it will be announced, wheter the examination will be organised in written or oral form.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none

Remarks	• Study programme Physics M.Sc.: Compulsory elective module in complex „Physical Specialization with Experimental Focus“, topic area „Nanophysics“ • Study programme Informatik M.Sc.: Compulsory elective module in minor „Maschinenbau/Elektrotechnik“ • Study programme Micro- and Nanoelectronics M.Sc.: Compulsory elective module in complex „Technology and Devices“
Module Components	• Lecture Semiconductor Technology • Related examination
Components to be offered in the Current Semester	**112210** Lecture/Exercise Semiconductor Technology - 2 Hours per Term **112211** Examination Semiconductor Technology

Module 13016 Characterization of Micro- and Nanomaterials

assign to: Technology and Devices

Study programme Micro- and Nanoelectronics

Degree	Module Number	Module Form
Master of Science	13016	Compulsory elective

Modul Title	**Characterization of Micro- and Nanomaterials** Charakterisierung von Mikro- und Nanomaterialien
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr. rer. nat. habil. Flege, Jan Ingo
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	On special announcement
Credits	6
Learning Outcome	After successfully completing the module, students have caught a good grasp of experimental methods for the characterization of micro- and nanomaterials. They are able to familiarize themselves with a technical topic independently. Additionally, students have continually improved presentation skills and further competences as accurateness, endurance and curiosity.
Contents	The following topics serve as examples to illustrate the connection between basic and applied sciences and to demonstrate the methods of attaining new perceptions: • internal stress and x-ray diffractometry, • elastic waves and elastic properties, • deformation analysis in the micro and nano regime, • Scanning probe microscopy, • focused ion beam, • nanoindenters, • thermography and thermal investigation of electrical micro-devices, • Laser techniques, • simulations for reliability testing, • compound materials
Recommended Prerequisites	• Sound knowledge of physics at or beyond the bachelor level.
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 4 hours per week per semester Self organised studies - 120 hours

Teaching Materials and Literature	• Will be offered during the first lecture.
Module Examination	Final Module Examination (MAP)
Assessment Mode for Module Examination	• Written examination, 120 min. **OR** With small number of participants it is also possible to organize the assessment mode as: • Oral examination, 30-45 min. **OR** • Presentation, 30-45 min. In the first lecture it will be announced, if the examination will be offered as written exam, oral exam or presentation.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	• Study programme Physics M.Sc.: Compulsory elective module in complex „Physical Specialization with Experimental Focus“, topic area „Condensed Matter Physics“ • Study programme Micro- and Nanoelectronics M.Sc.: Compulsory elective module in complex „Technology and Devices“ Self organized studies comprise: • reworking of the lecture, • reading of original papers (in English).
Module Components	• Lecture: Characterizatin of Micro- and Nanomaterials • Related exam
Components to be offered in the Current Semester	No assignment

Module 13019 Micro Systems

assign to: Technology and Devices

Study programme Micro- and Nanoelectronics

Degree	Module Number	Module Form
Master of Science	13019	Compulsory elective

Modul Title	**Micro Systems** Mikrosystemtechnik
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr.-Ing. Dr. rer. nat. habil. Schenk, Harald
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	After successful completion of the module, the students master the basics of silicon-based microsystems technology. Using the module's topic as an example, they understand the methods of gaining knowledge and know exemplary applications. In addition, social competences such as the ability to cooperate, as well as other individual competences such as diligence, perseverance, curiosity, initiative, frustration tolerance, etc. were promoted in the students.
Contents	• Introduction to silicon technology: materials, film deposition and structuring, surface- and volume-micromechanics, overview of equipment technology. • Physical principles of efficiency: basic physical principles of efficiency of simple sensors and actors (e.g. electrostatic, piezoelectric and magnetic effects). • Proposal of complex sensors and actors: overview of systematics and methodology, simple simulation examples for the calculation of dynamic properties of MEMS sensors. • Function and properties of complex sensors and actors: e.g. light modulators, acceleration sensors, gyroscope, scanner mirror.
Recommended Prerequisites	• Sound knowledge of solid state physics at or beyond the bachelor level.
Mandatory Prerequisites	none

Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 1 hours per week per semester Self organised studies - 135 hours
Teaching Materials and Literature	• M. Madou, "Fundamentals of Microfabrication„, CRC Press , Boca Raton-NewYork (2002) • Gianchandani, Yogesh B.; Tabata, Osamu; Zappe, Hans P.: „Comprehensive Microsystems“, Vol. 1-3, Elsevier, Amsterdam (2008) A detailed bibliography will be provided in the first lecture.
Module Examination	Prerequisite + Final Module Examination (MAP)
Assessment Mode for Module Examination	**Prerequisite:** • Successful seminar talk (with written part) **Final module examination:** • Written examination, 120 minutes
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	• Study programme Physics M.Sc.: Compulsory elective module in complex „Physical Specialization with Experimental Focus“, topic area „Nanophysics“ • Study programme Micro- and Nanoelectronics M.Sc.: Compulsory elective module in complex „Technology and Devices“ Self-organized studies are composed of: • reworking of lecture • literature work • preparation of a talk
Module Components	• Lecture: Micro Systems • Accompanying exercise • Related examination
Components to be offered in the Current Semester	**152210** Lecture Micro Systems - 2 Hours per Term **152211** Exercise Micro Systems - 1 Hours per Term **152212** Examination Micro Systems

Module 13020 Laboratory Techniques and Metrology

assign to: Technology and Devices

Study programme Micro- and Nanoelectronics

Degree	Module Number	Module Form
Master of Science	13020	Compulsory elective

Modul Title	**Laboratory Techniques and Metrology** Labor- und Messtechnik
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr.-Ing. Dr. rer. nat. habil. Schenk, Harald
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	After successfully completing the module, students have acquired an adequate and structured professional and general knowledge about the field of modern laboratory techniques and metrologies and have learned how to connect various concepts of this field. Moreover, social competences like cooperation capacity and individual competencies like accuracy, perseverance, curiosity, own initiative, tolerance against frustration have been supported.
Contents	Ray optical and wave optical description of optical systems including introduction to Fourier-Optics to describe the performance of optical metrology systems Principle, properties and use of • Laser vibrometer • White light interferometer • Ellipsometer • Scanning Electron Microscopy • Energy Dispersive X-Ray Spectroscopy • Profilometer • Nanointendation • Lock-In amplifier
Recommended Prerequisites	• Basic knowledge in physics (optics, electromagnetism) and electrical engineering
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Seminar - 1 hours per week per semester

	Self organised studies - 135 hours
Teaching Materials and Literature	• List of literature will be presented at first lecture.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• seminar talk, 20 minutes, with written part, 10 pages (50%) • written exam, 75 minutes (50%)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	10
Remarks	• Study programme Physics M.Sc.: Compulsory elective module in complex „Physical Specialization with Experimental Focus“, topic area „Nanophysics“ • Study programme Micro-and Nanoelectronics M.Sc.: Compulsory elective module in complex „Technology and Devices“
Module Components	• Lecture: Laboratory Techniques and Metrology • Accompanying seminar • Related examination
Components to be offered in the Current Semester	**152220** Lecture Laboratory Techniques and Metrology - 2 Hours per Term **152221** Exercise Laboratory Techniques and Metrology - 1 Hours per Term **152222** Examination Laboratory Techniques and Metrology (Re-examination only)

Module 13021 Surface Physics and 2D Materials

assign to: Technology and Devices

Study programme Micro- and Nanoelectronics

Degree	Module Number	Module Form
Master of Science	13021	Compulsory elective

Modul Title	**Surface Physics and 2D Materials** Oberflächenphysik und 2D-Materialien
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr. rer. nat. habil. Flege, Jan Ingo
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	After successful completion of the module, the students master the basics of experimental and theoretical concepts of surface physics. Using the example of the topic of this module, they know methods for gaining knowledge, classify physical findings in the overall context and cross link the individual results. In addition, they can apply social competences such as the ability to cooperate as well as other individual competences such as accuracy, patience, curiosity, initiative, etc.
Contents	• Morphology and structure of surfaces • Thermodynamics of surfaces • Adsorption and diffusion on surfaces • Nucleation and growth • Electronic properties of surfaces • Optical and magnetic properties of surfaces • Chemical reactions on surfaces • Production of two-dimensional materials • Structural properties of two-dimensional materials • Electronic properties of two-dimensional materials
Recommended Prerequisites	• Knowledge of solid state physics and chemistry based on a Bachelor study course in physics.
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 4 hours per week per semester Exercise - 2 hours per week per semester

	Self organised studies - 90 hours
Teaching Materials and Literature	• H. Ibach – Physics of Surfaces and Interfaces • H. Lüth – Solid Surfaces, Interfaces and Thin Films • K. Kolasinski – Surface Science • A. Zangwill – Physics at Surfaces
Module Examination	Final Module Examination (MAP)
Assessment Mode for Module Examination	• Oral examination, 30-45 min.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	• Study programme Physics M.Sc.: Compulsory elective module in complex „Physical Specialization with Experimental Focus“, topic area „Condensed Matter Physics“ • Study programme Micro- and Nanoelectronics M.Sc.: Compulsory elective module in complex „Technology and Devices“ Self organised studies comprise: • analysis and evaluation of the lectures • preparation of short reports • planning of exercise tasks
Module Components	• Lecture: Surface Physics and 2D Materials • Accompanying exercises • Related Examination
Components to be offered in the Current Semester	No assignment

Module 13024 Light and Matter: Introduction

assign to: Technology and Devices

Study programme Micro- and Nanoelectronics

Degree	Module Number	Module Form
Master of Science	13024	Compulsory elective

Modul Title	**Light and Matter: Introduction** Licht und Materie: Grundlagen
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr. rer. nat. habil. Fischer, Inga Anita
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	After successfully completing the module, students are acquainted with the foundations of light-matter interaction as well as selected applications in material analysis. They not only know how to acquire scientific knowledge but are also able to place physical phenomena into a more general context while exploring links between the different topics. In addition, students possess personal skills such as the capability for teamwork, precise reasoning, perseverance and openmindedness.
Contents	• Review of selected phenomena (including refraction, absorption, spectral lines, black body radiation, idealized climate model) • Optical spectroscopy • Drude-Lorentz model • Electromagnetic waves at interfaces • Nonlinear optics • Laser • Nonclassical light • Concepts of quantum photonics
Recommended Prerequisites	• Knowledge of physics at or beyond the bachelor level
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Seminar - 2 hours per week per semester Self organised studies - 90 hours

Teaching Materials and Literature	Will be announced during the first lecture: textbooks, scientific publications.
Module Examination	Final Module Examination (MAP)
Assessment Mode for Module Examination	• Written examination, 90 min. **OR** alternatively and depending on the number of student attendees: • an oral examination, 30-45 min. **OR** • a presentation, 30-45 min. are possible. The choice of exam (written, oral or presentation) will be announced in the first lecture.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	• Study programme Physics B.Sc.: Compulsory elective module in complex „Physical Specialised Module“ • Study programme Physics M.Sc.: Compulsory elective module in complex „Physical Specialization with Experimental Focus“, topic area „Nanophysics“ • Study programme Micro- and Nanoelectronics M.Sc.: Compulsory elective module in complex „Technology and Devices“ Self-study comprises revising the lecture. The accompanying seminar comprises: • reading scientific publications • preparation of oral presentations
Module Components	• Lecture: „Light and Matter: Introduction“ • Accompanying exercise • Accompanying seminar: journal club • Related examination
Components to be offered in the Current Semester	**150420** Lecture Light and Matter: Introduction - 2 Hours per Term **150421** Exercise Light and Matter: Introduction - 2 Hours per Term **150422** Seminar Journal Club Light and Matter: Introduction - 2 Hours per Term **150423** Examination Light and Matter: Introduction

Module 13025 Light and Matter: Interaction in Nanostructures

assign to: Technology and Devices

Study programme Micro- and Nanoelectronics

Degree	Module Number	Module Form
Master of Science	13025	Compulsory elective

Modul Title	**Light and Matter: Interaction in Nanostructures** Licht und Materie: Wechselwirkung in Nanostrukturen
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr. rer. nat. habil. Fischer, Inga Anita
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	On special announcement
Credits	6
Learning Outcome	After successfully completing the module, students are acquainted with the fundamentals of light-matter interaction in nanostructured semiconductors and metals and have gained insight into current research topics. They not only know how to acquire scientific knowledge but are also able to place physical phenomena into a more general context while exploring links between the different topics. In addition, students have acquired personal skills such as the capability for teamwork, precise reasoning, perseverance and openmindedness.
Contents	• Introduction to the interaction of light and matter: Dielectric functions • Coating systems • Semiconductor Bloch equations • Absorption spectra of semiconductor nanostructures • Plasmons • Photonic crystals and metamaterials • Semiconductor quantum dots
Recommended Prerequisites	• Sound knowledge of physics at bachelor level
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Seminar - 2 hours per week per semester Self organised studies - 90 hours

Teaching Materials and Literature	Will be announced during the first lecture: textbooks, scientific publications.
Module Examination	Final Module Examination (MAP)
Assessment Mode for Module Examination	• Written examination, 90 min. **OR** alternatively and depending on the number of student attendees: • an oral examination, 30-45 min. **OR** • a presentation, 30-45 min are possible. The choice of exam (written, oral or presentation) will be announced in the first lecture.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	• Study programme Physics M.Sc.: Compulsory elective module in complex „Physical Specialization with Experimental Focus“, topic area „Nanophysics“ • Study programme Micro- and Nanoelectronics M.Sc.: Compulsory elective module in complex „Technology and Devices“ Self-study comprisse: • revising the lectures • reading of scientific publications • preparation of oral presentations
Module Components	• Lecture: „Light and Matter: Interaction in Nanostructures“ • Accompanying exercise • Accompanying laboratory • Related examination
Components to be offered in the Current Semester	**150424** Examination Light and Matter: Interaction in Nanostructures

Module 13752 Advanced Micro Systems, Focus on Microsensors

assign to: Technology and Devices

Study programme Micro- and Nanoelectronics

Degree	Module Number	Module Form
Master of Science	13752	Compulsory elective

Modul Title	**Advanced Micro Systems, Focus on Microsensors** Fortgeschrittene Mikrosystemtechnik, Schwerpunkt auf Mikrosensoren
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr.-Ing. habil. Ruffert, Christine
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	After successful completion of the module, students have in-depth knowledge in the field of silicon-based microsystems technology, especially in the area of microsensor technology. They are able to analyze problems in this field and to develop solutions to problems, In addition, social competencies such as the ability to cooperate, as well as other individual competencies such as diligence, perseverance, curiosity, initiative, frustration tolerance, etc. were promoted in the students.
Contents	• Differentiation of sensors, transducers, actuators • Classification of sensors according to operating principles and intended use • Characteristics of sensors such as linearity, hysteresis, resolution • Analogue and digital sensors From elementary sensors to signal processing • Design, mode of operation and properties of selected capacitive, optical, chemical, acoustic and ultrasonic sensors • Application areas of sensors • Signal conditioning • Current research activities in microsensor technology • Principles and examples of microactuators and microtransducers
Recommended Prerequisites	• Sound knowledge of solid state physics at or beyond the bachelor level • Knowledge of the topics of module 13019 *Micro Systems*
Mandatory Prerequisites	none

Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Seminar - 1 hours per week per semester Self organised studies - 135 hours
Teaching Materials and Literature	• M. Madou, "Fundamentals of Microfabrication„, CRC Press , Boca Raton-NewYork (2002) • Gianchandani, Yogesh B.; Tabata, Osamu; Zappe, Hans P.: „Comprehensive Microsystems“, Vol. 1-3, Elsevier, Amsterdam (2008) A detailed bibliography will be provided in the first lecture.
Module Examination	Prerequisite + Final Module Examination (MAP)
Assessment Mode for Module Examination	**Prerequisite:** • Successful seminar talk (with written part) **Final module examination:** • Written exam, 90 minutes
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	• Study programme Physics M.Sc.: Compulsory elective module in complex „Physical Specialization with Experimental Focus“, topic area „Nanophysics“ • Study programme Micro- and Nanoelectronics M.Sc.: Compulsory elective module in complex „Technology and Devices“ Self-organized studies are composed of: • reworking of lecture • literature work • preparation of a talk
Module Components	• Lecture: Advanced Micro Systems, Focus on Microsensors • Accompanying exercise • Related examination
Components to be offered in the Current Semester	No assignment

Module 14031 Physics of Modern Devices

assign to: Technology and Devices

Study programme Micro- and Nanoelectronics

Degree	Module Number	Module Form
Master of Science	14031	Compulsory elective

Modul Title	**Physics of Modern Devices** Physik moderner Bauelemente
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr. rer. nat. habil. Fischer, Inga Anita
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	After successfully completing the module, students are acquainted with concepts of quantum mechanics and solid state physics and their application to the description of modern devices as well as their relevance for nanoscience, nanotechnology and information technology using real-world examples. They not only know how to acquire scientific knowledge but are also able to place physical phenomena into a more general context while exploring links between the different topics. In addition, students possess personal skills such as the capability for teamwork, precise reasoning, perseverance and openmindedness.
Contents	• Quantum mechanics - fundamental concepts relevant to the description of modern devices • Solid state physics - fundamental concepts relevant to the description of modern devices • Band structure calculations: Graphene • Effective mass theory and tunneling currents in semiconductor devices • Application examples (Flash memory, tunnel diodes, quantum effects in MOSFETs, ...)
Recommended Prerequisites	Knowledge of physics at a level corresponding to the first four semesters of a Bachelor’s degree in physics or corresponding to the level of a Bachelor’s degree in electrical engineering.
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester

	Exercise - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	• A. F. J. Levi, Applied Quantum Mechanics Will be added during the first lecture: scientific publications.
Module Examination	Final Module Examination (MAP)
Assessment Mode for Module Examination	• Written exam, 90 minutes
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	• Study programme Physik B.Sc.: Compulsory elective module in complex „Physikalisches Vertiefungsfach“ • Study programme Physics M.Sc.: Compulsory elective module in complex „Physical Specialization with Experimental Focus“, topic area „Nanophysics“ • Study programme Micro- and Nanoelectronics M.Sc.: Mandatory module for students without a Bachelor's degree in physics • Study programme Micro- and Nanoelectronics M.Sc.: Compulsory elective module in complex „Technology and Devices“ (if no mandatory module)
Module Components	• Lecture: Physics of Modern Devices • Accompanying exercise • Related examination
Components to be offered in the Current Semester	**152260** Lecture Physics of Modern Devices - 2 Hours per Term **152261** Exercise Physics of Modern Devices - 2 Hours per Term **152262** Examination Physics of Modern Devices

Module 14033 Advanced Micro- and Nanoelectronic Devices

assign to: Technology and Devices

Study programme Micro- and Nanoelectronics

Degree	Module Number	Module Form
Master of Science	14033	Compulsory elective

Modul Title	**Advanced Micro- and Nanoelectronic Devices** Moderne Bauelemente der Mikro- und Nanoelektronik
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr. rer. nat. habil. Fischer, Inga Anita
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	On special announcement
Credits	6
Learning Outcome	After successfully completing the module, students are acquainted with background for state-of-art microelectronic technologies and related integration techniques for advanced systems. The students are able to understand relations, dependencies and challenges for the continuous improvement of electronic systems.
Contents	Lectures will address advancements such as More Moore and functional extension of complex semiconductor technologies as well as novel device concepts such as FinFET, multi-bridge-MOS, etc. • Development/History of semiconductor technologies • Process background • MOS device evolution and functionality • Large scale integration technologies – from Denard scaling towards sub-10nm FET technologies • Integration methods (monolithic, hybrid, quasi-monolithic)
Recommended Prerequisites	Knowledge of topics of physics at a level corresponding to the first four semesters of a Bachelor’s degree in physics or corresponding to the level of a Bachelor’s degree in electrical engineering.
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Self organised studies - 120 hours

Teaching Materials and Literature	• Springer Handbook of Semiconductor Devices (2023), Editors: Massimo Rudan, Rossella Brunetti, Susanna Reggiani Will be specified during the first lecture: textbooks, scientific publications.
Module Examination	Final Module Examination (MAP)
Assessment Mode for Module Examination	• Oral exam, 45 minutes
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	• Study programme Micro- and Nanoelectronics M.Sc.: Compulsory elective module in complex „Technology and Devices"
Module Components	• Lecture: Advanced Micro- and Nanoelectronic Devices • Accompanying exercise • Related examination
Components to be offered in the Current Semester	**150460** Lecture Advanced Micro- and Nanoelectronic Devices - 2 Hours per Term **150461** Exercise Advanced Micro- and Nanoelectronic Devices - 2 Hours per Term **150462** Examination Advanced Micro- and Nanoelectronic Devices

Module 14295 Semiconductor Physics for Applied Quantum Structures

assign to: Technology and Devices

Study programme Micro- and Nanoelectronics

Degree	Module Number	Module Form
Master of Science	14295	Compulsory elective

Modul Title	**Semiconductor Physics for Applied Quantum Structures** Halbleiterphysik für angewandte Quantenstrukturen
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr. rer. nat. habil. Wenger, Christian
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	On special announcement
Credits	6
Learning Outcome	After successfully completing the module, students can handle the basics of experimental solid state physics concerning theoretical and methodical aspects. In particular, they will be proficient in spectroscopic methods.They are able to bridge the theoretical and experimental aspects of spectroscopic methods in solid state physics to provide an appropriate framework for the interpretation and modeling of experimental results. Thus, they are able to grasp new frontiers in the development of innovative applications. Based on the topics of this module, they know methods for gaining knowledge, the classify physical findings into the overall context and the cross link individual outcomes. Furthermore, they can apply their social competences like cooperation skills as well as other individual competences like accuracy, patience, curiosity, their own initiative.
Contents	• Foundation for Quantum Devices: Understanding the critical role of semiconductors in quantum device environments. • Heterostructure Growth and Characterization: Techniques for fabricating and characterizing high-quality quantum structures like quantum dots and wells. • Band Theory and Quantum Mechanics: Theoretical frameworks, including tight binding and k#p methods, for designing and analyzing quantum materials. • Mechanical and Electrical Properties: Exploring the impact of mechanical properties on band structure and optimizing electrical and transport properties for qubit performance.

	• Semiconductor Devices as Building Blocks: Basics of semiconductor devices such as transistors and diodes, essential for complex quantum devices. • Quantum Processes: Mastering processes like entanglement and superposition, crucial for quantum computing and communication. • Tunnel Devices and Qubits: Principles and practical aspects of devices exploiting quantum tunneling and qubits, fundamental to quantum computers. • Hands-on Learning: Practical sessions focused on reading research papers and identifying key insights, visit to IHP labs.
Recommended Prerequisites	• Knowledge of solid state physics and chemistry based on a Bachelor study course in physics
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	• G. Grosso and G. Pastori Parravicini *Solid State Physics*, Academic Press (2014) • C. Kittel *Introduction to Solid State Physics*, Wiley (2004) • P. Yu, M. Cardona *Fundamentals of Semiconductors*, Springer (2010) • Sze, S.M. *Physics of Semiconductor Devices,* Wiley (2021)
Module Examination	Final Module Examination (MAP)
Assessment Mode for Module Examination	• Oral examination, 30-45 min.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	• Study programme Physics M.Sc.: Compulsory elective module in complex „Physical Specialization with Experimental Focus“, topic area „Condensed Matter Physics“ • Study programme Micro- and Nanoelectronisc M.Sc.: Compulsory elective module in complex „Technology and Devices“
Module Components	• Lecture: Semiconductor Physics for Applied Quantum Structures • Accompanying exercises • Related examination
Components to be offered in the Current Semester	**152110** Lecture Semiconductor Physics for Applied Quantum Structures - 2 Hours per Term **152111** Seminar/Exercise Semiconductor Physics for Applied Quantum Structures - 4 Hours per Term **152112** Examination Semiconductor Physics for Applied Quantum Structures

Module 14446 Neuromorphic Engineering

assign to: Technology and Devices

Study programme Micro- and Nanoelectronics

Degree	Module Number	Module Form
Master of Science	14446	Compulsory elective

Modul Title	**Neuromorphic Engineering** Neuromorphe Technologie
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr. rer. nat. habil. Wenger, Christian
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	On special announcement
Credits	6
Learning Outcome	After successfully completing the module, students will have understand the principles of biological computation. They will know how to implement them in hardware. They will have basic skills in applying neuromorphic engineering.
Contents	Neuromorphic computing is an approach which is inspired by the structure and function of human brains. Neuromorphic computers are based on Silicon devices which use physical artificial neurons and synapses to apply computations. In recent times, the term neuromorphic has been used to describe analog, digital, mixed-mode analog/digital VLSI, and software systems that implement models of neural systems. The implementation of neuromorphic computing on the hardware level can be realized by oxide-based resistive or ferro-electric memristors. The lecture presents the principles of biological computation and their implementation in hardware. Basic building blocks of neuromorphic technology are presented. The implications for the development of novel information processing technologies are outlined.
Recommended Prerequisites	• Basic knowledge in physics
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Self organised studies - 150 hours
Teaching Materials and Literature	Will be announced in the first lecture.
Module Examination	Final Module Examination (MAP)

Assessment Mode for Module Examination	• Oral examination, 30-45 min.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	40
Remarks	• Study programme Physics M.Sc.: Compulsory elective module in complex „Minor Subject“ • Study programme Micro- and Nanoelectronics M.Sc.: Compulsory elective module in complex „Technology and Devices“
Module Components	• Lecture: Neuromorphic Engineering • Related examination
Components to be offered in the Current Semester	No assignment

Module 14490 Advanced Laboratory Techniques and Metrology

assign to: Technology and Devices

Study programme Micro- and Nanoelectronics

Degree	Module Number	Module Form
Master of Science	14490	Compulsory elective

Modul Title	**Advanced Laboratory Techniques and Metrology** Fortgeschrittene Labor- und Messtechnik
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr.-Ing. Dr. rer. nat. habil. Schenk, Harald
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	Upon successful completion of the module, students will have a thorough and organized understanding of advanced techniques for characterizing nanostructures, ultrathin films, and nanocomposites, as well as their essential role in modern micro/nano systems and semiconductor devices. They can recognize how the performance, functionality, and reliability of these devices are closely tied to the quality of these components.

Contents	• Fundamentals and importance of various advance measurement techniques
	• Principles, properties and Application of e.g.
	  • X-Ray Diffractometer
	  • Raman Spectroscopy
	  • Optical Coherence Tomography
	  • Ultrasound Spectroscopy
	  • Mass Spectroscopy

Recommended Prerequisites	• Basic knowledge in physics (optics, electromagnetism) and electrical engineering • Knowledge of the topics of module 13020 Laboratory Techniques and Metrology
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Seminar - 1 hours per week per semester

	Self organised studies - 135 hours
Teaching Materials and Literature	• Suryanarayana, C., et al., *X-ray diffraction: A practical approach, Springer New York, NY* (1998). • Ferraro, John R. *Introductory raman spectroscopy*. Elsevier, 2003. • Schneider, Simon. *Optical coherence tomography for characterization of nanocomposite materials*. KIT Scientific Publishing, 2021. • Gericke, OTTO R. "Ultrasonic spectroscopy." *Nondestructive Evaluation of Materials*. Boston, MA: Springer US, 1979. 299-320. • Watson, J. Throck, and O. David Sparkman. *Introduction to mass spectrometry: instrumentation, applications, and strategies for data interpretation*. John Wiley & Sons, 2007.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• seminar talk, 20 minutes, with written part, 10 pages (50%) • written exam, 75 minutes (50%)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	10
Remarks	• Study programme Physics M.Sc.: Compulsory elective module in complex „Physical Specialization with Experimental Focus“, topic area „Nanophysics“ • Study programme Micro- and Nanoelectronics M.Sc.: Compulsory elective module in complex „Technology and Devices“
Module Components	• Lecture: Advanced Laboratory Techniques and Metrology • Accompanying seminar • Related examination
Components to be offered in the Current Semester	No assignment

Module 12883 Advanced Seminar Electrical Engineering / Information Technology

assign to: Circuit Design

Study programme Micro- and Nanoelectronics

Degree	Module Number	Module Form
Master of Science	12883	Compulsory elective

Modul Title	**Advanced Seminar Electrical Engineering / Information Technology** Oberseminar Elektrotechnik/Informationstechnik
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr.-Ing. Rudolph, Matthias
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	The students master the methodologies required for independent scientific work in the field of electrical engineering. They are informed about the current research projects of their fellow students and have deepened their expertise in a field relevant to them beyond the level of their degree program.
Contents	• Researching and citing literature - Access to literature via databases and libraries. - Evaluation of the literature found. - Citing, refering to and using literature. - Research the state of the art for a concrete example. • Publishing - Forms of publication Journal Publication, Letter, Conference Proceedings. - Identification of the relevant publication form and medium. - Structure of an article or monograph. - Presentation of results and evidence in the technical-scientific field. - Criteria in peer review and review procedures. - Writing a text in a publishable form for a concrete example. • Presenting - Structure of a technical-scientific talk. - Content and formal design of a talk. - Design of visual aids. - Audience and external framework. - Preparation and presentation of your own 20-minute presentation. • Planning and execution of research projects

- Defining research goals.
- Working methods and schedules.
- Documentation of results.
- Teamwork and cooperation.
- DFG, BMBF and EU funding programmes.
- Sketch of a concrete research proposal.

• Discussion of current research results of all participants of the seminar.
• If necessary, relevant topics for the students will be addressed in the field of electrical engineering.

Recommended Prerequisites	none
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Seminar - 2 hours per week per semester Self organised studies - 150 hours
Teaching Materials and Literature	will be presented at the beginning of the module
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• Presentation of a literature research, approx. 5 min (30%) • Writing a scientific text in the form of a publication, 2-3 pages (40%) • Presentation of a scientific paper, 20 min (30%)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	20
Remarks	• Study programme Micro- and Nanoelectronics M.Sc.: Compulsory elective module in complex „Circuit Design“ The module is aimed at students who work independently on a research project, e.g. in the context of an assistance activity or a graduation thesis. In the seminar „Student Group Work“ the students prepare together the presentations in the advanced seminar and impart to each other the technical bases as well as scientific approaches and results of their own research activity.
Module Components	• Seminar Advanced Seminar Electrical Engineering / Information Technology
Components to be offered in the Current Semester	No assignment

Module 14030 Radio Frequency Application-Specific Integrated Circuit Design

assign to: Circuit Design

Study programme Micro- and Nanoelectronics

Degree	Module Number	Module Form
Master of Science	14030	Compulsory elective

Modul Title	**Radio Frequency Application-Specific Integrated Circuit Design** Anwendungsspezifischer Hochfrequenz Schaltkreisentwurf
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr.-Ing. Rudolph, Matthias
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	After successfully completing the module, students are familiar with basic concepts of RF-ASIC design. They will not only know how to acquire scientific knowledge, but will also be able to place phenomena related to the lecture topics in a more general context and explore connections between the different topics. In addition, students have personal skills such as teamwork, precise thinking, perseverance and open-mindedness.
Contents	• Operation and applications of typical microwave circuits such as mixers, oscillators and broadband amplifiers. • Design methods for these circuits. • Limitations and non-linear effects. • Practical aspects of the design with a circuit simulator.
Recommended Prerequisites	Knowledge of topics of physics and electrical engineering at a level corresponding to the first four semesters of a Bachelor’s degree in electrical engineering or corresponding to the level of a Bachelor’s degree in physics
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Seminar - 2 hours per week per semester Self organised studies - 150 hours
Teaching Materials and Literature	• H. L. Hartnagel, R. Quay, U. L. Rohde, and M. Rudolph, Eds., Fundamentals of RF and Microwave Techniques and

Technologies. Cham: Springer International Publishing, 2023. doi: 10.1007/978-3-030-94100-0
- Ulrich Tietze, Christoph Schenk, Eberhard Gamm, Electronic Circuits - Handbook for Design and Application, Springer-Verlag Berlin Heidelberg 2008, doi.org/10.1007/978-3-540-78655-9
- G. D. Vendelin, A. M. Pavio, U. L. Rohde, and M. Rudolph, Microwave circuit design: using linear and nonlinear techniques, Third edition. Hoboken, N.J., USA: Wiley, 2021.
- U. L. Rohde and M. Rudolph, RF / Microwave /Circuit Design for Wireless Applications/. John Wiley & Sons, 2013.

Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	As part of the module, students learn in the form of three largely independent projects, each of which is dedicated to one type of circuit. The following are assessed for each of the three parts: • The results of the circuit design, demonstrated by submission of the simulation and evaluation file of the circuit simulator (50%) • A final report of max. 10 pages (50%) All three projects are weighted equally for the calculation of the overall grade.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	20
Remarks	• Study programme Micro- and Nanoelectronics M.Sc.: Compulsory elective module in complex „Circuit Design“
Module Components	• Seminar Radio Frequency Application-Specific Integrated Circuit Design
Components to be offered in the Current Semester	No assignment

Module 14032 Introduction to Microwave Electronics

assign to: Circuit Design

Study programme Micro- and Nanoelectronics

Degree	Module Number	Module Form
Master of Science	14032	Compulsory elective

Modul Title	**Introduction to Microwave Electronics** Einführung in die Mikrowellenelektronik
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr.-Ing. Rudolph, Matthias
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	After successfully completing the module, students are acquainted with basic principles of microwave electronics. They not only know how to acquire scientific knowledge but are also able to exploit their knowledge of individual physical phenomena to develop technical solutions in a systematic engineering way.
Contents	• Bipolar and field-effect transistor physics and operation • Basic electronic concepts • Transmission-line theory • Linear multiport theory • Electronic noise
Recommended Prerequisites	Knowledge of topics of physics and electrical engineering at a level corresponding to the first four semesters of a Bachelor’s degree in electrical engineering or corresponding to the level of a Bachelor’s degree in physics
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 3 hours per week per semester Exercise - 2 hours per week per semester Self organised studies - 105 hours
Teaching Materials and Literature	• H. L. Hartnagel, R. Quay, U. L. Rohde, and M. Rudolph, Eds., Fundamentals of RF and Microwave Techniques and Technologies. Cham: Springer International Publishing, 2023. doi: 10.1007/978-3-030-94100-0

- Ulrich Tietze, Christoph Schenk, Eberhard Gamm, Electronic Circuits - Handbook for Design and Application, Springer-Verlag Berlin Heidelberg 2008, doi.org/10.1007/978-3-540-78655-9
- G. D. Vendelin, A. M. Pavio, U. L. Rohde, and M. Rudolph, Microwave circuit design: using linear and nonlinear techniques, Third edition. Hoboken, N.J., USA: Wiley, 2021.
- U. L. Rohde and M. Rudolph, RF / Microwave /Circuit Design for Wireless Applications/. John Wiley & Sons, 2013.

Module Examination	Final Module Examination (MAP)
Assessment Mode for Module Examination	• Written exam, 90 min.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	• Study programme Micro- and Nanoelectronics M.Sc.: Mandatory module for students without a Bachelor's degree in electrical engineering • Study programme Micro- and Nanoelectronics M.Sc.: Compulsory elective module in complex „Circuit Design“ (if no mandatory module)
Module Components	• Lecture: Introduction to Microwave Electronics • Accompanying exercise • Related examination
Components to be offered in the Current Semester	**112130** Lecture Introduction to Microwave Electronic - 3 Hours per Term **112131** Exercise Introduction to Microwave Electronic: - 2 Hours per Term **112132** Examination Introduction to Microwave Electronic:

Module 14047 Selected Chapters in Microwave Electronics

assign to: Circuit Design

Study programme Micro- and Nanoelectronics

Degree	Module Number	Module Form
Master of Science	14047	Compulsory elective

Modul Title	**Selected Chapters in Microwave Electronics** Ausgewählte Kapitel der Mikrowellenelektronik
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr.-Ing. Rudolph, Matthias
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	After completing the module, students will be familiar with the basic topics of microwave electronics and the methods and tools of circuit design. In addition to the theoretical knowledge, they will also know the basics of the practical use of common design and evaluation tools such as circuit simulators, network analyzer measurements and measurement evaluation with Python or Matlab. Furthermore, they can reflect on and structure their work and work independently in teams.
Contents	This module covers advanced topics in the field of microwave electronics: • Extraction of the small-signal equivalent circuit of a microwave transistor • Design of a power amplifier • Design of a bandpass filter in microstrip technology Basic prior knowledge of transmission line theory, S-parameters, and transistor fundamentals is necessary. For this module, students learn in the form of three largely independent projects. Presence at the seminar in the first week of the lecture period is required.

Recommended Prerequisites	Knowledge of the content of the module • 33328 Grundlagen der Hochfrequenztechnik OR • 14032 Introduction to Microwave Electronics OR • 14823 Introduction to Radio Frequency Technique This module covers advanced topics in the field of microwave electronics. Basic knowledge of transmission line theory, S-parameters, and transistor fundamentals is required.
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Seminar - 2 hours per week per semester Self organised studies - 150 hours
Teaching Materials and Literature	• G. D. Vendelin, A. M. Pavio, U. L. Rohde, and M. Rudolph, Microwave circuit design: using linear and nonlinear techniques, Third edition. Hoboken, N.J., USA: Wiley, 2021. • H. L. Hartnagel, R. Quay, U. L. Rohde, and M. Rudolph, Eds., Fundamentals of RF and Microwave Techniques and Technologies. Cham: Springer International Publishing, 2023. doi: 10.1007/978-3-030-94100-0.
Module Examination	Continuous Assessment (MCA)

Assessment Mode for Module Examination	• 3 projects, which are weighted equally for the calculation of the overall grade, and each evaluated as follows:
	  • Regular presence at and active contribution to the discussions in the seminar (30%)
	  • Results of the sub-projects, demonstrated by submission of the extraction, simulation or design file (circuit simulator, Matlab or Python) (35%)
	  • A final report of max. 10 pages (35%)

Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	20
Remarks	• Study programme Micro- and Nanoelectronics M.Sc.: Compulsory elective module in complex „Circuit Design“
Module Components	• Seminar Selected Chapters in Microwave Eletronics
Components to be offered in the Current Semester	**112120** Seminar Selected Chapters in Microwave Electronics - 2 Hours per Term

Module 14074 Radio Frequency Measurement Techniques

assign to: Circuit Design

Study programme Micro- and Nanoelectronics

Degree	Module Number	Module Form
Master of Science	14074	Compulsory elective

Modul Title	**Radio Frequency Measurement Techniques** Hochfrequenz-Messtechnik
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr.-Ing. Rudolph, Matthias
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	After successfully completing the module, students know to measure which radio frequency quantities. They are familiar with common measurement systems and calibration procedures. They can estimate measurement uncertainty and know strategies to determine relevant quantities from raw measurement data.
Contents	In this project laboratory, students acquire a sound knowledge of network analysis. For this purpose, a network analyzer including calibration and measurement routines is realized on the basis of a kit and used for the characterization of two-ports. The students are introduced to the theory of network analysis and are continuously supervised during the semester.
Recommended Prerequisites	• Basic knowledge of radio frequency and microwave electronics • Basic knowledge of Python or Matlab
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Practical training - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	• Hiebel, Michael: Fundamentals of vector network analysis, München, Rohde & Schwarz, 2011 • Rauscher, Christoph; Janssen, Volker; Minihold, Roland: Fundamentals of spectrum analysis, München, Rohde & Schwarz, 2011

Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	In order to do justice to the character of a project laboratory, working methods and results achieved as well as the final written and oral presentation of the work are included in the overall grade as follows: • Realization of the network analyzer including the implementation of the calibration routines (40%). • measurement of test two-port devices and interpretation of the measurement results (20%) • written final report, 15-25 pages, with presentation of results, 10-15 min (Scope depends on the processed project task.) (40%)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	20
Remarks	• Study programme Micro- and Nanoelectronics M.Sc.: Compulsory elective module in complex „Circuit Design“
Module Components	• Lecture: Radio Frequency Measurement Techniques • Accompanying practical training
Components to be offered in the Current Semester	No assignment

Module 14086 Microwave CAD

assign to: Circuit Design

Study programme Micro- and Nanoelectronics

Degree	Module Number	Module Form
Master of Science	14086	Compulsory elective

Modul Title	**Microwave CAD** Mikrowellen-CAD
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr.-Ing. Rudolph, Matthias
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	After successfully completing the module, students are familiar with state-of-the-art microwave design tools. They have practical experience with the design of hybrid microwave circuits, e.g., by designing a low-noise amplifier, and are capable to design a microwave circuit autonomuosly.
Contents	In this lab, hybrid low-noise amplifiers are designed by small groups of students. The basic design tool is ADS by Agilent or an equivalent. The students are introduced into the use of the simulation software, and into the basics of microwave circuit design. A main part is the design of the circuit which is done in autonomous small groups of students. Supervision is available throughout the project. One or more designs are selected, built and measured. This way, a full design cycle is completed. At the end, the students present their work, followed by a discussion of the results.
Recommended Prerequisites	• Basic knowledge of radio frequency and microwave electronics
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Seminar - 2 hours per week per semester Practical training - 2 hours per week per semester Self organised studies - 150 hours
Teaching Materials and Literature	• G. D. Vendelin, A. M. Pavio, U. L. Rohde, and M. Rudolph, Microwave circuit design: using linear and nonlinear techniques, Third edition. Hoboken, N.J., USA: Wiley, 2021

Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	To meet the character of a project laboratory performance and achieved results as well as the final written and oral presentation of the work contribute as follows to the final grade: • Circuit design of a project task (30%) • Construction and measuring circuit (30%) • Final written report, 10-15 pages, with presentation of results, 10-15 minutes; amount depends on project task (40%) The layout of the circuit board must be ready by the specified deadline, otherwise it cannot be manufactured and the module is not passed.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	20
Remarks	• Study programme Micro- and Nanoelectronics M.Sc.: Compulsory elective module in complex „Circuit Design“
Module Components	• Practical training Microwave CAD
Components to be offered in the Current Semester	No assignment

Module 14316 Antennas I

assign to: Circuit Design

Study programme Micro- and Nanoelectronics

Degree	Module Number	Module Form
Master of Science	14316	Compulsory elective

Modul Title	**Antennas I** Antennen I
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr.-Ing. Dr.-Ing. habil. Ndip, Ivan
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	After successfully completing the module, students will be acquainted with the fundamental theory of antenna radiation, the main differences between hertzian and magnetic dipole radiators as well as with the radiation characteristics of different configurations of dipole, monopole and loop antennas. The students will also be familiar with the theory of linear and planar antenna arrays as well as with methods for antenna synthesis. Furthermore, they will know techniques for measuring the S-parameters of antennas.
Contents	• Introduction • Fundamental theory of antenna radiation • Antenna parameters from circuit and field points of views • Hertzian and magnetic dipole radiators • Linear wire antennas: Dipole and monopole antennas • Loop antennas • Antenna arrays • Antenna synthesis • Antenna measurements: S-parameter
Recommended Prerequisites	none
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Self organised studies - 120 hours

Teaching Materials and Literature	• Lecture notes • Constantine A. Balanis: Antenna Theory, Analysis and Design, Wiley; 4th Edition, 2016 • John D. Kraus: Antennas For All Applications, McGraw-Hill , 3rd Edition, 2003 • Klaus W. Kark: Antennen und Strahlungsfelder, Springer Vieweg; 9th Edition, 2022 • Warren L. Stutzman, Gary A. Thiele: Antenna Theory and Design, Wiley; 3rd Edition, 2012
Module Examination	Final Module Examination (MAP)
Assessment Mode for Module Examination	• Oral exam, 30-45 min. OR • Written exam, 90 min. In the first lectures it will be announced whether the examination will be conducted in written or oral form.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	• Study programme Physics M.Sc.: Compulsory elective module in complex „Minor Subject“ • Study programme Micro- and Nanoelectronics M.Sc.: Compulsory elective module in complex „Circuit Design” • Study programme Künstliche Intelligenz Technologie M.Sc.: Compulsory elective module in complex „Hardware-basierte Systeme" In order to acquire practical knowledge, students are recommended to also take the course "Antenna Design Laboratory I (14318)".
Module Components	• Lecture: Antennas I • Exercise to the lecture • Related examination
Components to be offered in the Current Semester	**112320** Lecture Antennas I - 2 Hours per Term **112321** Exercise Antennas I - 2 Hours per Term **112322** Examination Antennas I

Module 14317 Antennas II

assign to: Circuit Design

Study programme Micro- and Nanoelectronics

Degree	Module Number	Module Form
Master of Science	14317	Compulsory elective

Modul Title	**Antennas II** Antennen II
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr.-Ing. Dr.-Ing. habil. Ndip, Ivan
Language of Teaching / Examination	English
Duration	6 semesters
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	After successfully completing the module, students will be acquainted with the theory and characteristics of a variety of antenna configurations used in the development of modern wireless systems. Furthermore, the students know methods for measuring the radiation pattern and gain of antennas.
Contents	• Introduction • Aperture antennas • Horn antennas • Microstrip patch antennas • Reflector antennas • Travelling wave antennas and broadband antennas • Measurements of antennas: Radiation pattern and gain • Application of antennas in wireless systems
Recommended Prerequisites	none
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	• Lecture notes • Constantine A. Balanis: Antenna Theory, Analysis and Design, Wiley; 4th Edition, 2016

- John D. Kraus: Antennas For All Applications, McGraw-Hill , 3rd Edition, 2003
- Klaus W. Kark: Antennen und Strahlungsfelder, Springer Vieweg; 9th Edition, 2022
- Warren L. Stutzman, Gary A. Thiele: Antenna Theory and Design, Wiley; 3rd Edition, 2012

Module Examination	Final Module Examination (MAP)
Assessment Mode for Module Examination	• Oral exam, 30-45 min. OR • Written exam, 90 min. In the first lectures it will be announced whether the examination will be conducted in written or oral form.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	• Study programme Physics M.Sc.: Compulsory elective module in complex „Minor Subject“ • Study programme Micro- and Nanoelectronics M.Sc.: Compulsory elective module in complex „Circuit Design” If required, all concepts in the lectures of this module can also be explained in German. Please speak to the professor responsible.
Module Components	• Lecture: Antennas II • Exercise to the lecture • Related examination
Components to be offered in the Current Semester	No assignment

Module 14318 Antenna Design Laboratory I

assign to: Circuit Design

Study programme Micro- and Nanoelectronics

Degree	Module Number	Module Form
Master of Science	14318	Compulsory elective

Modul Title	**Antenna Design Laboratory I** Antennendesign Praktikum I
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr.-Ing. Dr.-Ing. habil. Ndip, Ivan
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	After successfully completing the module, students will be able to model, simulate and analyze single elements of an antenna configuration using a 3D field solver, e.g. Ansys HFSS. They will also be able to create layouts of the antenna elements and perform S-parameter measurements.
Contents	• Basic concepts of antenna design • Introduction to high-frequency modelling and simulation of antennas using 3D field solvers, e.g. Ansys HFSS • Practical design and layout of an antenna element, selected from the antenna configurations in module “Antennas I” or module “Grundlagen der Antennen” • Investigation of the impact of the geometrical parameters of the antenna elements and substrate materials on antenna characteristics using a 3D field solver • S-parameter measurements • Documentation of results
Recommended Prerequisites	Knowledge of the content of one of the following modules • 14316 – *Antennas I* OR • 14315 – *Grundlagen der Antennen*
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Practical training - 4 hours per week per semester

	Study project - 60 hours Self organised studies - 60 hours
Teaching Materials and Literature	• Lecture notes • Constantine A. Balanis: Antenna Theory, Analysis and Design, Wiley; 4th Edition, 2016 • Warren L. Stutzman, Gary A. Thiele: Antenna Theory and Design, Wiley; 3rd Edition, 2012
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• Practical design, approx. 10 pages (60%) • Presentation with professional discussion, approx. 25 min. (40%)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	• Study programme Physik B.Sc.: Compulsory elective module in complex „Physikalisches Vertiefungsfach“ • Study programme Physics M.Sc.: Compulsory elective module in complex „Minor Subject“ • Study programme Micro- and Nanoelectronics M.Sc.: Compulsory elective module in complex „Circuit Design“ • Study programme Künstliche Intelligenz Technologie M.Sc.: Compulsory elective module in complex „Hardware-basierte Systeme“ If required, all concepts in the lectures of this module can also be explained in German. Please speak to the professor responsible.
Module Components	• Practical training: Antenna Design Laboratory I
Components to be offered in the Current Semester	No assignment

Module 14319 Antenna Design Laboratory II

assign to: Circuit Design

Study programme Micro- and Nanoelectronics

Degree	Module Number	Module Form
Master of Science	14319	Compulsory elective

Modul Title	**Antenna Design Laboratory II** Antennendesign Praktikum II
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr.-Ing. Dr.-Ing. habil. Ndip, Ivan
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	After successfully completing the module, students will be able to model, simulate and analyze simple arrays of an antenna configuration using a 3D field solver (e.g. Ansys HFSS). They will also be able to create layouts of the antenna arrays and perform both S-parameter and radiation pattern measurements.
Contents	• Practical design and layout of an antenna array, selected from the antenna configurations in the module “Antennas II”. • Investigation of the impact of the geometrical parameters of an antenna array and substrate materials on the characteristics of the array using a 3D field solver • S-parameter and radiation pattern measurements • Documentation of results
Recommended Prerequisites	Knowledge of the content of the following module: • 14318 – *Antenna Design Laboratory I* • 14317 – *Antennas II*
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Practical training - 4 hours per week per semester Study project - 60 hours Self organised studies - 60 hours
Teaching Materials and Literature	• Lecture notes • Constantine A. Balanis: Antenna Theory, Analysis and Design, Wiley; 4th Edition, 2016

	• Warren L. Stutzman, Gary A. Thiele: Antenna Theory and Design, Wiley; 3rd Edition, 2012
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• Practical design, approx. 10 pages (60%) • Presentation with professional discussion, approx. 25 min. (40%)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	• Study programme Physics M.Sc.: Compulsory elective module in complex „Minor Subject“ • Study programme Micro- and Nanoelectronics M.Sc.: Compulsory elective module in complex „Circuit Design” This module can also be offered in German if required. Please speak to the professor responsible.
Module Components	• Practical training: Antenna Design Laboratory II
Components to be offered in the Current Semester	**112330** Practical training Antenna Design Laboratory II - 4 Hours per Term

Module 14320 Signal/Power Integrity and Electromagnetic Compatibility

assign to: Circuit Design

Study programme Micro- and Nanoelectronics

Degree	Module Number	Module Form
Master of Science	14320	Compulsory elective

Modul Title	**Signal/Power Integrity and Electromagnetic Compatibility** Signal-/Powerintegrität und Elektromagnetische Verträglichkeit
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr.-Ing. Dr.-Ing. habil. Ndip, Ivan
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	After successfully completing the module, students will be acquainted with a) root causes of signal integrity (SI), power integrity (PI) and electromagnetic compatibility (EMC) issues in electronic systems, b) basic electromagnetic field and circuit concepts for analysis of SI, PI and EMC issues, especially in electronic packaging for radio frequency (RF) and high-speed systems.
Contents	• Introduction to signal integrity (SI), power integrity (PI) and electromagnetic compatibility (EMC) • Signal distribution networks (SDNs) and power delivery networks (PDNs) in electronic systems • Role of electronic packaging and heterogeneous integration technologies on signal and power integrity (SIPI) and EMC • Basic electromagnetic field and circuit theories for SIPI and EMC • SI: Analysis of single-ended and differential signal paths of SDNs • PI: Analysis of impedance, inductance and capacitance of PDNs • EMC: Analysis of coupling and undesired radiation • EMC & SIPI: Introduction to design methodologies for SIPI and EMC
Recommended Prerequisites	none
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Self organised studies - 120 hours

Teaching Materials and Literature	• Lecture notes • Stephen H. Hall, Howard L. Heck: Advanced Signal Integrity for High-Speed Digital Designs, Wiley 2009 • Paul G. Huray: The Foundations of Signal Integrity, Wiley, 2009 • Clayton Paul: Introduction to Electromagnetic Compatibility, Wiley, 2006 • Larry D. Smith, Eric Bogatin: Principles of Power Integrity for PDN Design-Simplified: Robust and Cost Effective Design for High Speed Digital Products, Prentice Hall, 2017 • Madhavan Swaminathan, Ege Engin: Power Integrity Modeling and Design for Semiconductors and Systems, Prentice Hall, 2007
Module Examination	Final Module Examination (MAP)
Assessment Mode for Module Examination	• Oral exam, 30-45 min. OR • Written exam, 90 min. In the first lectures it will be announced whether the examination will be conducted in written or oral form.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	• Study programme Physics M.Sc.: Compulsory elective module in complex „Minor Subject“ • Study programme Micro- and Nanoelectronics M.Sc.: Compulsory elective module in complex „Circuit Design” If required, all concepts in the lectures of this module can also be explained in German. Please speak to the professor responsible.
Module Components	• Lecture: Signal/Power Integrity and Electromagnetic Compatibility • Exercise to the lecture • Related examination
Components to be offered in the Current Semester	No assignment

Module 14334 Data Converters

assign to: Circuit Design

Study programme Micro- and Nanoelectronics

Degree	Module Number	Module Form
Master of Science	14334	Compulsory elective

Modul Title	**Data Converters** Datenumsetzer
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr.-Ing. Killat, Dirk
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	On special announcement
Credits	6
Learning Outcome	The students are familiar with the structure and application of Nyquist rate and oversampling AD and DA converters. They understand the specification, areas of application, advantages and disadvantages of the respective converter and can make an appropriate selection for an application. They can describe a Nyquist rate and delta sigma ADC in Matlab / Simulink and simulate the specification.
Contents	**Lecture (Theory)** • Repetition of basics: sampling, quantization, noise, DFT, windowing, Z-transformation • Specification: operating modes, static and dynamic properties, test of DNL, INL, distortions • Nyquist rate AD and DA converters: architectural elements, resistive and capacitive dividers, R2R networks, mismatch, trimming, hybrid DACs, power source-based DACs, segmentation, flash converters, sub-ranking and folding techniques, SAR and pipeline ADCs, analog blocks such as regenerative comparators and clock generators • Oversampling AD and DA converters: 1st-order modulator, noise shaping, STF and NTF, higher-order NTF, SC integrator and SC circuit techniques, comparator and clock scheme, multi-bit quantizers, DEM, cascaded modulators, resonators, decimation filters, sinc filters, time-continuous modulator **Seminar/Laboratory** • Introduction Matlab / Simulink • Simulation techniques, spectral analyzes, DNL and INL • Modeling individual components of a Nyquist rate ADC

	• Sequence control with Simulink / Stateflow • Simulation of non-ideal components in NR-ADCs • Delta-Sigma Toolbox • Design of discrete-time modulators • Design of continuous-time modulators • Influence of non-ideal components • Evaluation of a specification
Recommended Prerequisites	Knowledge of the contend of modules • 33315 *Analoge Schaltungen* • 11909 *Systemtheorie II* • as well as knowledge and practical experience with Matlab and Simulink
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Seminar - 1 hours per week per semester Practical training - 1 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	• Maloberti, F. (2007): Data converters. Dordrecht, Netherlands: Springer, Download via Springerlink: https://link.springer.com/book/10.1007%2F978-0-387-32486-9 • Pelgrom, Marcel J.M. (2013): Analog-to-Digital Conversion. 2nd ed. 2013. New York, Download via Springerlink: https://link.springer.com/content/pdf/10.1007%2F978-1-4614-1371-4.pdf • Handout of lecture notes (German / English) • Laboratory manual and assignments (German / English)
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	Two complex tasks are assigned in the laboratory, each contributing 30% to the overall grade. At the end of the lecture period a written test with a duration of 60 minutes takes place, which contributes 40% to the overall grade. • Task 1 in the lab: Nyquist rate ADC, approx. 5 pages incl. graphics plus the simulation files from Matlab (30%) • Task 2 in the lab: Delta Sigma ADC, approx. 5 pages incl. graphics plus the simulation files from Matlab (30%) • Written test, 60 minutes (40%)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	16
Remarks	• Study programme Micro- and Nanoelectronics M.Sc.: Compulsory elective module in complex „Circuit Design“ Students wishing to attend this module are kindly requested to get in touch with the module responsible at an early stage. Enrolment key for Moodle required.

Module Components	• Lecture: Data Converters • Accompanying combined seminar / laboratory • Related examination
Components to be offered in the Current Semester	No assignment

Module 14442 Radio Frequency Integrated Circuit Design Lab

assign to: Circuit Design

Study programme Micro- and Nanoelectronics

Degree	Module Number	Module Form
Master of Science	14442	Compulsory elective

Modul Title	**Radio Frequency Integrated Circuit Design Lab** Praxisorientierter Entwurf von integrierten Hochfrequenz-ICs
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr.-Ing. Kahmen, Gerhard
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	After successfully completing the module, students have an overview of radio frequency (RF) transceiver architectures, RF devices and active/passive microelectronic components. They are able to apply common software tools for the design, layout and verification based on a mixer circuit realized on an IHP high performance semiconductor technology. Students are able to go through the entire design cycle from specification, schematic entry, simulation, layout to validation of the tape-out capable design of an application specific integrated circuit (ASIC).
Contents	• Transceiver architectures and figures of merit • Introduction into active and passive microelectronic devices • RF-Mixer basics • RF-Mixer topologies • Introduction into Keysight ADS Design Framework • ASIC schematic design • Introduction into Cadence Virtuoso (layout / physical design) • ASIC Layout design • Introduction into 2.5D electromagnetic (EM) design • Circuit optimization • Design Rule Check (DRC) • Layout vs. Schematic • Virtual Tape Out
Recommended Prerequisites	• Knowledge of electrical engineering at a level corresponding to the first four semesters of a Bachelor’s degree in electrical engineering

	• Knowledge of the functioning and topology of electronic components, such as content of module 12364 Elektronische Bauelemente und Grundschaltungen • Basic knowledge of Analog circuit design, such content of module 33315 Analoge Schaltungen • Knowledge of the content of the module 14030 Radio Frequency Application-Specific Integrated Circuit Design
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Study project - 30 hours Self organised studies - 120 hours
Teaching Materials and Literature	• P.R. Gray, P.J. Hurst, S.H. Lewis, R.G. Meyer, „Analysis and Design of Analog Integrated Circuits“, John Whiley & Sons, 4th Edition, 2001 • S. Dimirijev, „Understanding Semiconductor Devices“, Oxford University Press, 2nd Edition • S. Voinigescu, „High-Frequency Integrated Circuits“, Cambridge University Press, 2013 • J.D. Cressler, G. Niu, „Silicon-Germanium Heterojunction Bipolar Transistors“, Artech House, 2003 • B. Razavi, „Design of Analog CMOS Integrated Circuits“, Mc Graw Hill 2001 Teaching material will be provided before each lecture.
Module Examination	Prerequisite + Final Module Examination (MAP)
Assessment Mode for Module Examination	**Prerequisite:** • Preparation of a design review presentation, approx. 30 hours **Final module examination:** • Defence of the design (design review) during the examination • Oral examination, approx. 45 min.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	15
Remarks	• Study programme Physics M.Sc.: Compulsory elective module in complex „Minor Subject“ • Study programme Informatik M.Sc.: Compulsory elective module in field of application „Maschinenbau/Elektrotechnik“ • Study programme Künstliche Intelligenz Technologie M.Sc.: Compulsory elective module in complex „Hardware-basierte Systeme“
Module Components	• Lecture Radio Frequency Integrated Circuit Design Lab • Related examination
Components to be offered in the Current Semester	No assignment

Module 14823 Introduction to Radio Frequency Techniques

assign to: Circuit Design

Study programme Micro- and Nanoelectronics

Degree	Module Number	Module Form
Master of Science	14823	Compulsory elective

Modul Title	**Introduction to Radio Frequency Techniques** Grundlagen der Hochfrequenztechnik
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr.-Ing. Rudolph, Matthias
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	The students know the basics of radio frequency techniques. They are familiar with the propagation of waves on transmission lines and resulting effects like reflections. They are able to calculate linear mulitports based on scattering parameters and know how to obtain matching. They know common active and passive RF devices.
Contents	1. Waves on lines • transmission-line equivalent circuit, line parameters • Coaxial cables and waveguides: modes, dispersion, losses 2. Reflection and Smith chart • Reflection coefficient, impedance transformation, standing waves • Smith chart • Matching circuits • Resonators, quality factor, bandwidth 3. S-parameters • Linear multi-ports, S-parameters • Mason graphs, Gain definitions, stability • Lossless multi-ports 4. Couplers and dividers • Couplers • Dividers, Wilkinson divider 5. Noise • Mathematical fundamentals

- Physical noise sources
- Noise figure, cascaded two-port networks
- Noise parameters

6. Semiconductor devices
- Diodes
- Field effect transistors
- Bipolar transistors

Recommended Prerequisites

Knowledge of topics of physics and electrical engineering at a level corresponding to the first four semesters of a Bachelor's degree in electrical engineering or corresponding to the level of a Bachelor's degree in physics

Mandatory Prerequisites

No successful participation in module 33328 Grundlagen der Hochfrequenztechnik

Forms of Teaching and Proportion

Lecture - 3 hours per week per semester
Exercise - 2 hours per week per semester
Self organised studies - 105 hours

Teaching Materials and Literature

- Hans L. Hartnagel, Rüdiger Quay, Ulrich L. Rohde, Matthias Rudolph (Eds.),
  Fundamentals of RF and Microwave Techniques and Technologies, Cham, Switzerland: Springer, 2023.
  ISBN: 978-3-030-94098-0, DOI: doi.org/10.1007/978-3-030-94100-0
  https://link.springer.com/book/10.1007/978-3-030-94100-0
- Michael H.W. Hoffmann, Hochfrequenztechnik - Ein systemtheoretischer Zugang, Springer-Lehrbuch 1997
  https://link.springer.com/book/10.1007/978-3-642-59089-4

Module Examination

Prerequisite + Final Module Examination (MAP)

Assessment Mode for Module Examination

Prerequisite:
- Successful completion of exercises (solving of the exercises and submission of a written solution to the exercise date)

Final module examination:
- Written examination, 120 min.

Evaluation of Module Examination

Performance Verification – graded

Limited Number of Participants

none

Remarks

- Study programme Micro- and Nanoelectronics M.Sc.: Compulsory elective module in complex „Circuit Design“

Module Components

- Lecture: Introduction to Radio Frequency Techniques
- Accompanying exercise
- Related examination

Components to be offered in the Current Semester

112110 Lecture
Introduction to Radio Frequency Technique (Grundlagen der Hochfrequenztechnik) - 3 Hours per Term
112111 Exercise

Introduction to Radio Frequency Technique (Grundlagen der Hochfrequenztechnik) - 2 Hours per Term
112113 Examination
Introduction to Radio Frequency Technique (Grundlagen der Hochfrequenztechnik)

Module 11864 Wireless Sensor Networks: Concepts, Protocols and Applications

assign to: Applications

Study programme Micro- and Nanoelectronics

Degree	Module Number	Module Form
Master of Science	11864	Compulsory elective

Modul Title	**Wireless Sensor Networks: Concepts, Protocols and Applications** Drahtlose Sensornetze: Konzepte, Protokolle und Anwendungen
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr.-Ing. Piotrowski, Krzysztof
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	Participants know the architecture of wireless sensor networks. They can select and classify protocols for different applications. Participants can design and understand complex protocols. They understand the connection between physical impacts on communication and necessary technical means to keep the network alive. They can design own networks and argue about the design decisions. They can judge about future developments.
Contents	Architecture of sensor networks, node-architectures, MAC protocols, addressing, routing, synchronisation, operating systems, topology management, applications, security and key-exchange protocols.
Recommended Prerequisites	Basic knowledge of technical computer science concepts and communication systems.
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	Are available on Moodle, starting from the first week of lectures.
Module Examination	Prerequisite + Final Module Examination (MAP)
Assessment Mode for Module Examination	**Prerequisite:** • Successful completion of exercise assignments

	Final module examination: • Written examination, 90 min. **OR** • Oral examination, 30 min. (with small number of participants) In the first lecture it will be anounced, if the examination will be offered in written or oral form.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	• Study programme Informatik B.Sc.: Compulsory elective module in complex "Angewandte und Technische Informatik" (level 300) • Study programme Cyber Security M.Sc.: Compulsory elective module in complex "Computer Science" • Study programme Künstliche Intelligenz Technologie M.Sc.: Compulsory elective module in complex „Software-basierte Systeme“ • Study programme Physics M.Sc.: Compulsory elective module in complex „Minor Subject“ • Study programme Micro- and Nanoelectronics M.Sc.: Compulsory elective module in complex „Applications“
Module Components	• Lecture/Exercise: Wireless Sensornetworks: Concepts, Protocolls and Applications • Related examination
Components to be offered in the Current Semester	**122130** Lecture/Exercise Wireless Sensor Networks: Concepts, Protocolls and Applications - 4 Hours per Term **122131** Examination Wireless Sensor Networks: Concepts, Protocolls and Applications

Module 13254 Image Based Measurement Techniques for Aerodynamics

assign to: Applications

Study programme Micro- and Nanoelectronics

Degree	Module Number	Module Form
Master of Science	13254	Compulsory elective

Modul Title	**Image Based Measurement Techniques for Aerodynamics** Bildgebende Messverfahren in der Aerodynamik
Department	Faculty 3 - Mechanical Engineering, Electrical and Energy Systems
Responsible Staff Member	Prof. Dr. rer. nat. Schröder, Andreas
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	The students will learn the (laser-) optical and electronic basics as well as suitable digital image processing and evaluation methods for various 2D- and 3D-image based measurement- and visualization methods (e.g. PIV, LPT, LIF, PSP, TSP, BOS, DIC etc.) for aerodynamics. Through relevant applications to unsteady and rotational flows and on surfaces of bodies immersed in such flows, the students will get to know the limits (systematic and signal-to-noise ratio-related measurement uncertainties) and possibilities of different optical (non-intrusive) measurement techniques. Equipped with this knowledge, the students learn the use of (statistical) analysis tools that can be applied to the experimentally achieved instantaneous or time-resolved planar or volumetric flow field data from industrial flow facilities or wind- and water tunnels in order to achieve a deeper understanding of the investigated flow properties and related (dynamical) forces and moments. The quantitative flow measurement data and their analysis should in turn enable the students to directly relate to the underlying Navier-Stokes equations, to validation procedures for (U)RANS and other CFD methods, to different models and dynamics of vortical flow structures, to aero-elastically coupled fluid-structure interactions or to the field of aero-acoustics.
Contents	Due to enormous advances in the field of digital camera, laser and LED technologies for spatially and temporally highly-resolved image acquisition on the one hand and the increased performance of computers and GPU clusters for digital image processing on the other hand, optical measurement techniques are in a rapid upswing and are increasingly replacing classic, sensor-based measurement techniques. In the lecture the theoretical, optical and technical basics,

	as well as current further developments and applications of image based measurement methods in the areas of aerodynamics, fluid mechanics, and aero-elasticity, as well as partly in aeroacoustics will be presented. In addition to methods that aim at the acquisition of aero-dynamically and -elastically relevant measurement variables such as the distribution of pressure, deformation, temperature or wall shear stress on model surfaces, optical methods for the planar and volumetric measurements of scalar quantities in flows, such as density, concentration or temperature are discussed. However, the greater part of the lecture will deal with the theory, application and evaluation of particle-based measurement methods for the planar and volumetric determination of instantaneous and time-resolved velocity, acceleration and pressure fields in unsteady flows, as well as with the possibilities of the subsequent data assimilation and analysis tools.
Recommended Prerequisites	• English language skills • Basic knowledge in fluid mechanics and optics
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	• Raffel et al. PIV a practical guide, 3rd edition (2018) • Tropea C., Yarin A.L., Foss J.F. (Eds.): Handbook of Experimental Fluid Mechanics, Springer Verlag (2007) • Schröder A., Willert C. (Eds.): Particle Image Velocimetry – New developments and recent applications, Springer Verlag (2007) • Selected literature
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• Completion of 7 practical training exercises and preparation of the respective reports of about 3 pages each (1/3 of the module grade). • Oral examination of approx. 30 min. duration (2/3 of the module grade)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	none
Module Components	• Lecture Image based measurement techniques for aerodynamics • Exercise Image based measurement techniques for aerodynamics • Exam Image based measurement techniques for aerodynamics
Components to be offered in the Current Semester	**352102** Lecture Image based measurement techniques for aerodynamics - 2 Hours per Term **352103** Exercise/Practical training Image based measurement techniques for aerodynamics - 2 Hours per Term

Module 13335 Brain-Computer Interfaces (BCIs) for Neuroadaptive Technology

assign to: Applications

Study programme Micro- and Nanoelectronics

Degree	Module Number	Module Form
Master of Science	13335	Compulsory elective

Modul Title	**Brain-Computer Interfaces (BCIs) for Neuroadaptive Technology** Brain-Computer-Interfaces für Neuroadaptive Technologien
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr. rer. nat. Zander, Thorsten O.
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every semester
Credits	6
Learning Outcome	After successfully completing the module, students possess a basic understanding of the methodology of Brain-Computer Interfaces (BCIs), including measurement of brain activity, signal processing, machine learning and the principle of automated interpretation of brain activity to assess information of changes in cognitive states. Furthermore, they are familiar with the use of BCIs in current and to-be-created human-computer interactions which includes the current development of beneficial Artificial Intelligence.
Contents	The module will consist of lectures describing the methodology and use of Brain-Computer Interfaces from the scratch. This includes knowledge from machine learning and signal processing, as well as psychophysiology and psychology, and human-computer interaction. In the seminar, students will be introduced to AI safety and the ethics of neurotechnology, and will prepare group presentations on various related topics and issues. Ethical issues and social consequences are discussed and guidelines for research and development are derived.
Recommended Prerequisites	none
Mandatory Prerequisites	Passing the exam of module • 13942: Foundations of Psychophysiology
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Seminar - 2 hours per week per semester Self organised studies - 120 hours

Teaching Materials and Literature	• Zander, T. O. (2011). Utilizing Brain-Computer Interfaces for Human-Machine Systems (Doctoral dissertation, Universitätsbibliothek der Technischen Universität Berlin).
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• active participation by asking questions during or after the classes (20%) • moderated discussion of selected topics related to the lecture, 45 minutes (30%) • written exam, 60 minutes (50%)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	72
Remarks	• Study programme Medizininformatik: B.Sc.: Compulsory elective module in complex „Medizininformatik" • Study programme Informatik M.Sc.: Compulsory elective module in complex „Praktischer Informatik" (level 400) • Study programme Artificial Intelligence M.Sc.: Compulsory elective module in complex „Learning and Reasoning“ • Study programme Künstliche Intelligenz Technologie B.Sc.: Compulsory elective module in complex „Kognitions- und Neurowissenschaft“ • Study programme Micro- and Nanoelectronics M.Sc.: Compulsory elective module in complex „Applications“ • Study programme Mathematical Data Science M.Sc.: Compulsory elective module in complex „Data Science Applications“ • Study programme Mathematics M.Sc.: Compulsory elective module in complex „Applications: Computer Science & Artificial Intelligence“
Module Components	• Lecture: Brain-Computer Interfaces (BCIs) for Neuroadaptive Technology • Accompanying seminar
Components to be offered in the Current Semester	**142110** Lecture Brain-Computer Interfaces (BCIs) for Neuroadaptive Technology - 2 Hours per Term **142112** Seminar Brain-Computer Interfaces (BCIs) for Neuroadaptive Technology - 2 Hours per Term **142114** Examination Brain-Computer Interfaces (BCIs) for Neuroadaptive Technology

Module 13942 Foundations of Psychophysiology

assign to: Applications

Study programme Micro- and Nanoelectronics

Degree	Module Number	Module Form
Master of Science	13942	Compulsory elective

Modul Title	**Foundations of Psychophysiology** Grundlagen der Psychophysiologie
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr. rer. nat. Zander, Thorsten O.
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every semester
Credits	6
Learning Outcome	After successfully completing the module, students possess an understanding of the physiological processes in the human body that lead to biomarkers of different mental states. They furthermore understand the principles of experimental design in the context of psychophysiology, and have experience reading, critiquing, and writing psychophysiological research literature.
Contents	The module consists of lectures and a seminar. The lectures cover relevant aspects of general human physiology as well as more specific processes that can be measured using electrocardiography (ECG, heart activity), electromyography (EMG, muscle activity), electrodermal activity (EDA, skin conductance), eye tracking, as well as brain activity through functional near-infrared spectroscopy (fNIRS) and electroencephalography (EEG). The techniques behind each of these methods are discussed as well, along with properties of the recorded signal and some known correlates of that signal to mental processes or psychological states. Ethical, social and legal issues arising from research into the use of psychophysiological data will be discussed. This includes the recording of data, data security, transparency and ethical issues relating to experiments. In the seminar, students will read, present and discuss relevant papers published in scientific journals, reflecting different experiments involving physiological data. Additionally, students will write an essay on a related topic.
Recommended Prerequisites	none

Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Seminar - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	• Andreassi, J. (2007). Psychophysiology: Human Behavior and Physiological Response (5th Edition). New York, NY, USA: Psychology Press • Gramann, K. & Schandry, R. (2009). Psychophysiologie (4. Auflage). Basel, Switzerland: Beltz • Selected scientific papers
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• written test, 60 minutes (60%) • discussion of selected topics related to the lecture as preparation for the term paper, 90 minutes (5%) • term paper, 6 pages (35%)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	72
Remarks	• Study programme Artificial Intelligence M.Sc.: Compulsory elective module in complex „Learning and Reasoning“ • Study programme Künstliche Intelligenz Technologie M.Sc.: Compulsory elective module in complex „Kognitions- und Neurowissenschaft“ • Study programme Medizininformatik B.Sc.: Compulsory elective module in complex „Medizininformatik“ • Study programme Micro- and Nanoelectronics M.Sc.: Compulsory elective module in complex „Applications“ • Study programme Mathematical Data Science M.Sc.: Compulsory elective module in complex „Data Science Applications“
Module Components	• Lecture: Foundations of Psychophysiology • Accompanying seminar
Components to be offered in the Current Semester	**142120** Lecture Foundations of Psychophysiology - 2 Hours per Term **142121** Seminar Foundations of Psychophysiology - 2 Hours per Term **142124** Examination Foundations of Psychophysiology **142125** Examination Foundations of Psychophysiology

Module 14362 Radar Systems

assign to: Applications

Study programme Micro- and Nanoelectronics

Degree	Module Number	Module Form
Master of Science	14362	Compulsory elective

Modul Title	**Radar Systems** Radarsysteme
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr.-Ing. Gardill, Markus
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	After successfully completing the module, students have an understanding of the fundamentals of radar systems.They can describe the propagation of electromagnetic waves in wireless channels in time and frequency domain. They are able to classify radar systems and their operating principles and parameters. and to model the kinematics of radar targets. Further they are able to analyse and classify radar methods, waveforms and their characteristics. They understand and apply essential steps in digital signal processing in radar systems. They are able to analyse radar systems at the system level.
Contents	Radar systems for applications in industry, transportation, medical technology, and remote sensing. This includes in particular an overview of radar systems, terminology, propagation of electromagnetic waves, kinematics of radar targets, modeling of transmit and receive power, radar waveforms, modeling of radar systems and radar signal processing. In the exercise, the contents of this lecture are consolidated by calculation examples, deepened in computer-based simulations and examples and finally applied in practical experiments with radar system hardware.
Recommended Prerequisites	none
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester

	Self organised studies - 120 hours
Teaching Materials and Literature	Lecture notes will be provided during the first class meeting.
Module Examination	Prerequisite + Final Module Examination (MAP)
Assessment Mode for Module Examination	**Prerequisite:** • successful performance in the practical experiments during the exercise **Final module examination:** • Oral examination, 30-45 min. **OR** • Written examination, 90 min. In the first lecture it will announced, whether the examination will organized in written or oral form.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	• Study programme Künstliche Intelligenz Technologie M.Sc.: Compulsory elective module in complex „Hardware-based Systems: Electrical Engineering, Information Technology and Sensor Technology“ • Study programme Micro- and Nanoelectronics M.Sc.: Compulsory elective module in complex „Applications“
Module Components	• Lecture: Radar Systems • Accompanying exercise • Related examination
Components to be offered in the Current Semester	**110180** Lecture Radar Systems - 2 Hours per Term **110181** Seminar/Practical training Radar Systems - 2 Hours per Term **110182** Examination Radar Systems

Erläuterungen

Das Modulhandbuch bildet als Teil der Prüfungsordnung die Rechtsgrundlage für ein ordnungsgemäßes Studium. Darüber hinaus soll es jedoch auch Orientierung bei der Gestaltung des Studiums geben.

Dieses Modulhandbuch wurde am 07. November 2025 automatisch für den Master (universitär)-Studiengang Micro- and Nanoelectronics (universitäres Profil), PO-Version 2024, aus dem Prüfungsverwaltungssystem auf Basis der Prüfungsordnung generiert. Es enthält alle zugeordneten Module einschließlich der ausführlichen Modulbeschreibungen mit Stand vom 07. November 2025. Neben der Zusammensetzung aller Veranstaltungen zu einem Modul wird zusätzlich das Veranstaltungsangebot für das jeweils aktuelle Semester gemäß dem Veranstaltungsverzeichnis der BTU ausgegeben.

The module catalogue is part of the examination regulation and as such establishes the legal basis for studies according to the rules. Furthermore, it should also give orientation for the organisation of the studies.

This module catalogue was generated automatically by the examination administration system on the base of the examination regulation on the 7 November 2025, for the Master (universitär) of Micro- and Nanoelectronics (research-oriented profile). The examination version is the 2024, Catalogue contains all allocated modules including the detailed module descriptions from 7 November 2025. Apart from the composition of all components of a module, the list of lectures, seminars and events for the current semester according to the catalogue of lectures of the BTU is displayed.