Module Handbook

Master‘s degree course
Master of Science Microelectronic Systems

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Program Objectives

The master's program aims to equip students with the ability to independently develop and deepen the knowledge and skills acquired during their studies and to apply scientific methods to complex problems in both practical and applied research settings. Graduates should be capable of thinking in systems and designing as well as implementing complex microelectronic systems, supported by the necessary theoretical foundations, methods, and tools. The program prepares students for careers in research, development, and application. The following provides a detailed description of the competencies to be acquired:

Professional Competence

- **System Development and Integration:** Graduates possess in-depth knowledge of the development, analysis, and integration of microelectronic systems, including digital and analog circuit design, embedded systems including sensors, and high-speed data transmission.
- **Technological Expertise:** They understand modern semiconductor and MEMS technologies, manufacturing processes, and current and emerging trends in microelectronics, enabling them to transfer new technologies into practical applications.
- **Applied Signal Processing:** They master advanced digital signal processing algorithms and their implementation on real-time hardware (DSPs, FPGAs) in order to solve complex engineering problems.
- **Machine Learning on Embedded Systems:** They can efficiently implement machine learning algorithms on resource-constrained embedded devices and optimize them for specific applications.

Methodological Competence

- **Design, Simulation and Measurement of Microelectronic Systems:** Graduates are capable of designing and simulating digital and analog circuits as well as integrated systems using state-of-the-art EDA tools. They are able to conduct measurements using modern laboratory equipment.
- **Research Competence:** They can apply scientific methods to independently identify research questions in microelectronics, conduct theoretical and experimental investigations, and develop scientifically based solutions.
- **Technical Management:** They can efficiently plan, manage, and implement complex development projects in the field of microelectronics.

Social Competence

- **Interdisciplinary Teamwork:** They can work collaboratively in interdisciplinary and international teams, effectively communicate technical solutions.
- **Technical Communication:** They can present technical concepts to different audiences, clearly convey scientific findings, and engage in discussions at a professional level.

Self-Competence

- **Innovation and Problem-Solving Skills:** Graduates can independently analyze complex technical challenges, develop solution strategies, and apply innovative technologies in practice.
- **Sustainability and Ethical Responsibility:** They understand the societal and environmental impact of microelectronic technologies and can integrate sustainable development goals into their technical work.
- **Lifelong Learning:** They are capable of continuously acquiring knowledge in new technological fields and deepening their expertise through self-directed learning and scientific advancement.

Overview of Modules

Winter semester (HAW Hamburg)	Summer semester (FH Westküste)	3rd semester
System on Chip	Microtechnology	Master Thesis / Colloquium
Embedded Signal Processing	Chip design	
Smart Sensor Systems	Machine Learning on Embedded Devices	
Sustainable Research Project 1	High Speed Digital Design	
General Elective Module 1	Sustainable Research Project 2	
	General Elective Module 2	

Assessment Types

a) **Examination (K)**
An examination is a supervised assignment in which students independently work on the given tasks without aids or by using only the permitted aids. Examinations in the multiple-choice format are excluded. The duration of an examination is at least 90 minutes and at most 180 minutes.

b) **Laboratory Completion (LA)**
A laboratory completion is successfully achieved when students have successfully carried out the experimental tasks assigned by the examiner during the semester and have demonstrated their knowledge through accompanying colloquia as described in letter c and/or written reports. The written reports must be submitted within a deadline set by the examiner. This deadline ends no later than the end of the semester in which the corresponding course type is held.

c) **Colloquium (Ko)**
A colloquium is an examination conversation that also serves to determine whether the work was completed independently. The duration of a colloquium is at least 15 minutes and at most 45 minutes.

d) **Oral Examination (M)**
An oral examination is an examination conversation in which students must demonstrate their mastery of the examination material. Oral examinations are conducted either individually or in groups. If not conducted as a collegial examination by two examiners, they are held in the presence of an observer who has at least the qualification being determined by the exam. The duration of an oral examination is at least 15 minutes and at most 45 minutes per examined person. With the consent of the examinee, and based on available space, members from both universities may be allowed as listeners. Students who wish to retake the same examination in the next exam period should be given preference. This admission does not extend to discussions and announcements of the examination results.

e) **Presentation (R)**
A presentation consists of a written and an oral part. The written part involves the completion of a task that expands or deepens the subject matter of the course. The completion time is at most six weeks and must be documented. In the oral part, the results of the written part are presented freely and defended in a subsequent discussion. The oral presentation lasts at least 15 minutes and at most 45 minutes.

f) **Home and Project Work (HA)**
A home and project work is a task where students, either alone or in groups, prepare a written report. In group work, the contribution of each individual must be clearly identifiable. The task may also require a presentation where the results of the work are reported. The time limit for completing a home and project work is a maximum of 12 weeks; if required, the oral presentation lasts at least 15 minutes and at most 45 minutes per examined person.

g) **Examination-like Computer Applications (KC)**
An examination-like computer application is a task using a relevant computer program, where students independently work on the assigned tasks without additional aids or by using only permitted aids. The duration of an examination-like computer application is at least 60 minutes and at most 120 minutes. It must be ensured that the electronic data can be unambiguously and permanently assigned to the individual students.

h) **Portfolio Examination (PP)**
A portfolio examination is a type of examination consisting of a maximum of six examination elements. For the portfolio examination, at least two different examination types according to letters a, c to g must be used. The instructor determines at the beginning of the course which examination elements and their weighting will be used for the portfolio examination. The individual examination elements, according to their weighting, contribute to an overall grade for the portfolio examination. The total scope of the portfolio examination, based on workload, must not exceed the scope of the examination format if it were chosen as the only examination element.

Module descriptions – Modules offered at HAW Hamburg

Microelectronic Systems (Master of Science)	
System on Chip (M1)	
Abbreviation	SOC / SOCL
Module responsibility	Prof. Dr. Peter Schulz
Duration / Semester/ Regular cycle	One semester / first or second semester / winter semester
Credits (CP) / Semester hours per week (SHW)	6 CP 3 + 1 SHW
Workload	Attendance: 68 h Self-study: 112 h
Type of module	Mandatory module
Prerequisites	Recommended: The prerequisite is the ability to describe and develop digital circuits and systems from various perspectives. The students should know a design flow starting with the description at the register transfer level (e.g. in VHDL) through the simulation to circuit synthesis. Furthermore, knowledge of hardware-related controller programming in C is expected.
Language	English
Learning outcomes	**Professional competence** • the students know application domains for systems-on-a-chip, • are able to compose systems-on-a-chip from computer components and other digital and analog functional units, • can name possibilities and criteria of dividing information technology problems into hardware and software domains. **Methodological competence** • The students are capable of designing basic system-on-a- chip with regard to hardware and software requirements, • are able to design systems and circuits and to verify them using an advanced hardware description language (e.g. SystemVerilog), • are capable of performing a HW-SW integration and hardware-related programming in a high-level programming language (e.g. C), • are mastering a front-end design flow through to implementation on programmable logic (FPGA).
Learning content	**Seminar-style class** • Computer architecture and components • Soft-core vs. hard macro processor • On-chip vs. off-chip memories • On-chip connection methods • Network on Chip • Clock distribution • FPGA architecture • application-specific functional units, • Co-processing basics and HW-accelerators

	• advanced hardware description language • Circuit synthesis • FPGA implementation • Embedded SW design (bare metal vs. OS-based) **Lab sessions (examples)** • Design, simulation and verification of digital functional units and/or special peripheral interfaces using hardware description language. • Software integration of special peripheral units. • Solving a more complex information technology task using the methods learned.
Usability of the module	Master program Microelectronic Systems
Requirements for recognition of credits **(Study and exam requirements)**	Typical examination types for module testing: Lecture: successful passing in written exam (K)(PL) Laboratory: successful participation in lab exercises (LA)(PVL) Further possible examination types: oral exam (M), presentation with paper (R). Where more than one possible examination type is used in the module, the examination type to be used is to be made known by the responsible lecturer at the start of the course.
Courses	SOC (Seminar-style class) SOCL (Laboratory)
Type of Media	SOC: Tuition in seminars; blackboard, slides, computer simulation SOCL: Practical course
Literature	In current issue: • Hubert Kaeslin, “Top-Down Digital VLSI Design – From Architectures to Gate-Level Circuits and FPGAs”, Elsevier Inc. • Stuart Sutherland, “RTL Modeling with SystemVerilog”, Sutherland HDL Inc. • Chris Spear, Greg Tumbush, “SystemVerilog for Verification”, Springer • Volnei A. Pedroni, “Finite State Machines in Hardware”, The MIT press • Louise Crockett et. Al., “The Zynq Book”, http://www.zynqbook.com/

Microelectronic Systems (Master of Science)	
Embedded Signal Processing (M2)	
Abbreviation	ESP / ESPL
Module responsibility	Prof. Dr. Lutz Leutelt
Duration / Semester/ Regular cycle	One semester / first or second semester / winter semester
Credits (CP) / Semester hours per week (SHW)	6 CP 3 + 1 SHW
Workload	Attendance: 68 h Self-study: 112 h
Type of module	Mandatory module
Prerequisites	Recommended: • Fundamental knowledge of discrete-time signal and system theory, • experience with the C programming language and Matlab or Python
Language	English
Learning outcomes	**Professional competence** The students • know important hardware architectures for implementation of signal processing algorithms and aspects of arithmetic with numbers of finite precision, • know relevant terms and methods of advanced signal processing algorithms. **Methodological competences** The students can • apply and parametrize mathematical methods and algorithms of signal processing to a specific problem, • simulate, parameterize, and evaluate signal processing algorithms with Matlab or Python, • implement signal processing algorithms on real-time hardware (e.g. digital signal processors or FPGAs) using a high-level programming language (like C), corresponding development tools and lab equipment. **Social competence** The students can • work on tasks in a small team and in a goal-oriented manner, • take the different perspectives and interests of other participants into account, • deal with intercultural situations consciously and appropriately. **Self-competence** The students can • analyse a given problem in the field of digital signal processing and develop and implement a solution taking performance, resource consumption and costs into account.
Learning content	• Introduction to architectures and devices (e.g. DSP, FPGA) for implementation of signal processing algorithms and effects of number representation with finite precision Selected topics in advanced signal processing from the following areas:

	• multirate systems, interpolation, decimation, filterbanks • statistical signal processing, parameter estimation, signal detection, optimal filtering • adaptive filtering and systems
Usability of the module	Master's degree program Microelectronic Systems Master's degree program Information and Communications Engineering
Requirements for recognition of credits (Study and exam requirements)	Typical examination types for module testing: Lecture: successful passing in written exam (K)(PL) Laboratory: successful participation in lab exercises (LA)(PVL) Further possible examination types: oral exam (M), presentation with paper (R). **Where more than one possible examination type is used in the module, the examination type to be used is to be made known by the responsible lecturer at the start of the course.**
Courses	ESP (Lecture) ESPL Laboratory)
Type of Media	ESP: Tuition in seminars; blackboard, slides, computer simulation ESPL: Practical course
Literature	In current issue: • Anastasia Veloni, Digital and Statistical Signal Processing, CRC Press, • S. Palani, Principles of Digital Signal Processing, Springer • D. Manolakis et al., Statistical and Adaptive Signal Processing: Spectral Estimation, Signal Modeling, Adaptive Filtering and Array Processing, McGraw-Hill Professional • R. Chassaing: DSP Applications using C and the TMS320C6x DSK, Wiley • K. Shafaei, TI DS6P step-by-step: C2000, C5000, and C6000, Independently published • U. Meyer-Baese, Digital Signal Processing with Field Programmable Gate Arrays

Microelectronic Systems (Master of Science)	
Smart Sensor Systems (M3)	
Abbreviation	SMS / SMSL
Module responsibility	Prof. Dr. Matthias Kronauge
Duration / Semester/ Regular cycle	One semester / first or second semester / winter semester
Credits (CP) / Semester hours per week (SHW)	6 CP 3 + 1 SHW
Workload	Attendance: 68 h Self-study: 112 h
Type of module	Mandatory module
Prerequisites	Recommended: Fundamentals of signals and systems (analog and digital) Fundamentals of digital signal processing Fundamentals of stochastics
Language	English
Learning outcomes	**Professional competence** The students know • working principles and properties of sensors for e.g.: o acceleration o position (distance, angle) o velocity • algorithms for o sensor data processing o fusion of data from multiple sensors **Methodological competence** The students can • choose for a given task o an appropriate sensor type o appropriate sensor data processing algorithm • implement automated sensor-based functions. **Self-competence** The students are capable of • analyzing a given problem in the field of sensor data acquisition and processing and develop and implement a suitable solution.
Learning content	**Lecture** • working principles and properties of different sensor types • sensor data processing methods **Laboratory** • Realization of a system of sensors for environment perception • Presentation of results
Usability of the module	Master's degree program Microelectronic Systems Master's degree program Information and Communications Engineering

Requirements for recognition of credits **(Study and exam requirements)**	Typical examination types for module testing: Lecture: successful passing in written exam (K) (PL) Laboratory: successful participation in exercises (LA) (PVL) Further possible examination types: oral exam (M), presentation with paper (R). **Where more than one possible examination type is used in the module, the examination type to be used is to be made known by the responsible lecturer at the start of the course.**
Courses	SMS (Lecture) SMSL (Laboratory)
Type of Media	SMS: Tuition in seminars; blackboard, slides, computer simulation SMSL: Practical course
Literature	In current issue: • Horst Czichos: Measurement, Testing and Sensor Technology: Fundamentals and Application to Materials and Technical Systems, Springer-Verlag, Berlin • Gerard Meijer, Michiel Pertijs, Kofi Makinwa: Smart Sensor Systems: Emerging Technologies and Applications, IEEE Press • Skolnik, Merrill I.: Radar handbook, McGraw-Hill, New York • Walter Lang: Sensors and Measurement Systems, River Publishers, New York, • Hesse, Stefan; Schnell, Gerhard: Sensoren für die Prozess- und Fabrikautomation. Springer Vieweg, Wiesbaden. • Tränkler, Hans-Rolf; Reindl, Leonhard M., Hrsg.: Sensortechnik - Handbuch für Praxis und Wissenschaft. Springer-Verlag, Berlin.

Microelectronic Systems (Master of Science)	
Sustainable Research Project 1 (M4)	
Abbreviation	SRP1
Module responsibility	Program coordinator HAW Hamburg (Prof. Dr. Lutz Leutelt)
Duration / Semester/ Regular cycle	One semester / first or second semester / winter semester
Credits (CP) / Semester hours per week (SHW)	6 CP 1 SHW
Workload	Attendance: 9h Self-study: 171h
Type of module	Mandatory module
Prerequisites	Recommended: knowledge of fundamentals of scientific work and project management Sustainable research projects SRP1 and SRP2 can be taken and completed in any order and can be chosen as different subject specializations or be continued in the same specialization over two semesters.
Language	English
Learning outcomes	**Professional competence** The students • know the sustainable development goals and their relevance, • can apply in-depth knowledge and refined methods in their focus field. **Methodological competence** The students are able to • explore a subject of this Master's degree program at greater depth by finding literature and scientific publications and acquisition of the required theoretical and practical knowledge, • organize the given subject by applying methods of project management to achieve the goal in an efficient and effective manner. **Social competence** The students can • work on scientific problems in a team in a goal-oriented manner, • find technical and factual solutions to problems by discussing with representatives and non-specialists of the subject, • organize professional discussions in a goal-oriented and constructive manner, • take the different perspectives and interests of other participants into account, • deal with intercultural situations consciously and appropriately. **Self-competence** The students are capable of • developing and solving research and development questions specific to their area of specialization, considering limited resources (e.g. time, staff, tools) and aspects of sustainable development, • manage themselves to fulfill tasks and complete the tasks by the scheduled deadline, • present subject-specific results plausibly in oral presentations or written reports and respond to questions professionally and

	appropriately.
Learning content	Students work in small groups on research-related project tasks relating to the topics of the Master's degree program. These are usually presented in a kick-off event by the university's research projects or, in individual cases, by cooperation partners from industry and research institutes who accompany the project and are subsequently selected by students. The small groups are each supervised by a professor in the development of the theoretical-scientific foundations, requirements analysis, concept development, implementation and evaluation. In a final conference, the small groups present their results in the form of short talks or poster presentations. The topic can be continued in the following semester or students can choose a new specialization.
Usability of the module	Master's degree program Microelectronic Systems Master's degree program Information and Communications Engineering Master's degree program Automatisierungstechnik
Requirements for recognition of credits **(Study and exam requirements)**	Typical examination types for module testing: Project: successful passing in presentation with paper (R) (SL) Further possible examination type: portfolio examination (PP). **Where more than one possible examination type is used in the module, the examination type to be used is to be made known by the responsible lecturer at the start of the course.**
Courses	SRP1 (small group project, KGP)
Type of Media	SRP1: (small group project, KGP) depending on chosen specialization: scientific publications, textbooks, datasheets and other literature, online resources, working independently in the project within a team
Literature	In current issue: • literature on scientific work, e.g.: Th. Deetjen, Published: a guide to literature review, outlining, experimenting, visualization, writing, editing, and peer review for your first scientific journal article, 2020 • literature on project management, e.g.: S.E.Portny, Project Management All-in-One, For Dummies, 2020 • literature on the chosen topic and specialization (recommended by supervising professor or as a result of students' literature study)

Microelectronic Systems (Master of Science)	
General Elective Module 1 (M5)	
Abbreviation	GEM1 / GEM1L
Module responsibility	Program coordinator HAW Hamburg (Prof. Dr. Lutz Leutelt)
Duration / Semester/ Regular cycle	One semester / first or second semester / winter semester
Credits (CP) / Semester hours per week (SHW)	6 CP 3 + 1 SHW
Workload	Attendance: 68 h Self-study: 112 h
Type of module	Mandatory elective module
Prerequisites	Elective modules deal with in-depth or supplementary content of Microelectronic Systems at Master's level. Students receive a description of the elective modules for the coming semester and recommended prior knowledge before the start of each semester. In principle, it is also possible to apply for courses from other faculties, provided the necessary prior knowledge is available and there are free places.
Language	English, German
Learning outcomes	The compulsory elective module serves either to deepen and specialize in the field of microelectronic systems or to strengthen interdisciplinarity by choosing a topic outside the field. **Professional competence** Students can • deepen and specialize in the field of microelectronic systems or • strengthen interdisciplinarity by choosing a topic outside the field. • distinguish and understand key concepts, approaches and perspectives that are specific to the respective field **Methodological competence** Students are able to • transfer general scientific methods and solution approaches to problems in the field of application • evaluate specific solution approaches in the field of application with regard to their advantages and disadvantages and apply them accordingly • follow specialist discourses (e.g. at specialist conferences or in specialist journals or forums) and actively participate in them where appropriate **Social competence** The students are able to • work on problems in a team in a goal-oriented manner, • discuss technical and factual solutions to problems with representatives of the subject and non-specialists and to argue theoretically and methodically sound. • consider the different perspectives and interests of other participants appropriately, • deal with intercultural and interdisciplinary situations consciously and

	appropriately. **Self-competence** The students are able • - work out concepts independently and acquire basic techniques or procedures in a new scientific field, • - manage themselves to fulfill tasks and complete the tasks by the scheduled deadline. • - present subject-specific results plausibly in oral presentations or written reports and respond to questions professionally and appropriately.
Learning content	The specific content of the module varies depending on the chosen course. The descriptions of the general elective modules are communicated to students before the start of each semester.
Usability of the module	Master's degree program Microelectronic Systems Master's degree program Information and Communications Engineering Master's degree program Automatisierungstechnik
Requirements for recognition of credits **(Study and exam requirements)**	Typical examination types for module testing: Lecture: successful passing in written exam (K)(PL) Laboratory: successful participation in exercises (LA)(PVL) Further possible examination types: oral exam (M), presentation with paper (R), portfolio (PP). **Where more than one possible examination type is used in the module, the examination type to be used is to be made known by the responsible lecturer at the start of the course.**
Courses	GEM1 (Seminar-style class) GEM1L (Laboratory)
Type of Media	GEM1: Tuition in seminars; blackboard, slides, computer simulation GEM1L: Practical course
Literature	See the description of the respective compulsory elective module

Module descriptions – Modules offered at FH Westküste

Microelectronic Systems (Master of Science)	
Microtechnology (M6)	
Abbreviation	MTY / MTYL
Module responsibility	Prof. Dr.-Ing. Sönke Appel
Duration / Semester/ Regular cycle	One semester / first or second semester / summer semester
Credits (CP) / Semester hours per week (SHW)	5 CP 4 SHW
Workload	Attendance: 60 h Self-study: 90 h
Type of module	Mandatory module
Prerequisites	Recommended: Basic knowledge on electronic components and physics of materials
Language	English
Learning outcomes	**Professional competence** The students • understand basic concepts of semiconductor physics, • know the most common manufacturing processes of semiconductors, • understand process sequences for the producing of integrated circuits, • know the current developments in the field of semiconductors and, • can name new technologies which may rise up on the market in the near future. **Methodological competence** The students • are able to determine the parameters of different semiconductor manufacturing processes.
Learning content	**Lecture** • Basic materials • Clean room technology • Quality management • Measurements and testing technology • Coating technology • Photolithography • Etching processes • Doping • Process integration **Exercise** Determine the parameter of different semiconductor manufacturing processes.
Usability of the module	Master's degree program Microelectronic Systems Master's degree program Automatisierungstechnik

Requirements for recognition of credits (Study and exam requirements)	Typical examination types for module testing: Lecture and Excercise: successful passing in written exam (K)(PL) Further possible examination types: oral exam (M), presentation with paper (R). **Where more than one possible examination type is used in the module, the examination type to be used is to be made known by the responsible lecturer at the start of the course.**
Courses	MTY (Lecture) MTYL (Exercise)
Type of Media	Blackboard, PowerPoint slides, computer simulations, interactive tools
Literature	In current issue: • Franssila, S., 2010. *Introduction to microfabrication*. John Wiley & Sons. • Gerlach, G. and Dotzel, W., 2008. *Introduction to microsystem technology: a guide for students*. John Wiley & Sons. • Globisch, S., 2011. *Lehrbuch Mikrotechnologie*. Fachbuchverl. Leipzig im Carl-Hanser-Verlag. • Thuselt, F., 2005. *Physik der Halbleiterbauelemente*. Springer-Verlag Berlin Heidelberg. • Ehrfeld, W., 2002. *Handbuch Mikrotechnik*. Hanser Verlag München Wien.

Microelectronic Systems (Master of Science)	
Chip Design (M7)	
Abbreviation	CHD / CHDL
Module responsibility	Prof. Dr.-Ing. Sönke Appel
Duration / Semester/ Regular cycle	One semester / first or second semester / summer semester
Credits (CP) / Semester hours per week (SHW)	5 CP 1 + 3 SHW
Workload	Attendance: 60 h Self-study: 90 h
Type of module	Mandatory module
Prerequisites	Recommended: Basic knowledge on electronic components and physics of materials
Language	English
Learning outcomes	**Professional competence** The students • understand the concept of full-custom and semi-custom ASIC design, • understand the design flow of digital chip design, • know the most common used fab technologies, • understand the concept of analog and digital standard-cells. **Methodological competence** The students • are able to design CMOS components and create logic standard-cells out of the designs, • are able to design function blocks with given logic standard- cells, • are capable of create digital own designs using a HDL, • are able to implement simple analog standard-cells and, • are able to implement simple mixed signal design by using an analog and digital standard-cells. **Self-competence** The students are able to plan, design and implement a small ASIC design with given requirements and share their results in a laboratory report. **Social competence** The students are able to work cooperative in a team to successfully complete an ASIC design task.
Learning content	**Lecture** • IC-Design basics • Semi-custom digital design flow • Analog design flow • Mixed signal design flow • From prototype to product • Analysis, simulation and test **Laboratory**

	• Digital standard-cell Design
	  ○ CMOS component simulation an optimization
	  ○ Design of standard logic cells
	  ○ Function block design
	• Digital IC Design
	  ○ Introduction to digital IC implementation flow
	  ○ Timing constraints
	  ○ Routing
	  ○ High level automatic test pattern generation
	• Analog IC Design
	  ○ Block-level and system level design flows
	  ○ Analogue design infrastructure
	  ○ Schematic entry and hierarchical design
	  ○ Parametric analysis
	  ○ DRC
	  ○ System level design
	• Introduction to Mixed Signal Design
	  ○ Digital-on-top methodology and flow
	  ○ IBIS models
	  ○ Digital implementation flow with analogue macros
	• Mixed signal designs and flow

Usability of the module	Master's degree program Microelectronic Systems Master's Master's degree program Automatisierungstechnik
Requirements for recognition of credits (Study and exam requirements)	Typical examination types for module testing: Lecture: successful passing in written exam (K)(PL) Laboratory: successful participation in lab exercises (LA)(PVL) Further possible examination types: oral exam (M), presentation with paper (R). **Where more than one possible examination type is used in the module, the examination type to be used is to be made known by the responsible lecturer at the start of the course.**
Courses	CHD (Lecture) CHDL (Laboratory)
Type of Media	Blackboard, PowerPoint slides, computer simulations, interactive tools, ASIC design tool chain
Literature	In current issue: • Razavi, B., 2021. *Fundamentals of microelectronics*. John Wiley & Sons. • Allen, P.E., Dobkin, R. and Holberg, D.R., 2011. *CMOS analog circuit design*. Elsevier. • Weste, N.H. and Harris, D., 2015. *CMOS VLSI design: a circuits and systems perspective*. Pearson Education India. • Rabaey, J.M., Chandrakasan, A.P. and Nikolic, B., 2002. *Digital integrated circuits* (Vol. 2). Englewood Cliffs: Prentice hall.

Microelectronic Systems (Master of Science)	
Machine Learning on Embedded Devices (M8)	
Abbreviation	MLE / MLEL
Module responsibility	N.N.
Duration / Semester/ Regular cycle	One semester / first or second semester / summer semester
Credits (CP) / Semester hours per week (SHW)	5 CP 2 + 2 SHW
Workload	Attendance: 60 h Self-study: 90 h
Type of module	Mandatory module
Prerequisites	Recommended: Basic knowledge in machine learning, digital signal processing and programming embedded hardware, Python.
Language	English
Learning outcomes	**Professional competence** • The students understand and are able to explain the main concepts of machine learning suitable for embedded hardware. • For appropriate problems they know how to systematically find suitable concepts based on machine learning (ML). **Methodological competence** • They know about machine efficient algorithms and are capable to implement ML algorithms using current programming languages and typical software frameworks. **Self-competence** • The students can adequately document their solution and reflect on it critically. **Social competence** • The students are able to divide appropriate tasks and work on them in a team using defined interfaces.
Learning content	**Lecture** The following topics are covered • Typical components of embedded systems a relevant constraints • Resource requirements of ML algorithms • Embedded a distributed ML architectures • ML models, software frameworks for ML (e.g. TinyML) • Hard- and software optimization **Laboratory** • Programming tasks in Matlab und on embedded systems. o
Usability of the module	Master's degree program Microelectronic Systems Master's degree program Automatisierungstechnik
Requirements for recognition of credits (Study and exam requirements)	Typical examination types for module testing: Laboratory: successful passing in written exam (K)(PL) Lecture: n/a Further possible examination types: oral exam (M), presentation with

	paper (R). **Where more than one possible examination type is used in the module, the examination type to be used is to be made known by the responsible lecturer at the start of the course.**
Courses	MLE (Lecture) MLEL (Laboratory)
Type of Media	Blackboard, PowerPoint slides, computer simulations, interactive tools
Literature	In current issue: • Pete Warden, Daniel Situnayake: “TinyML, Machine Learning with TensorFlow on Arduino, and Ultra-Low Power Micro-Controllers”, O'Reilly Media, 2019. • Paolo S.R. Diniz: “Signal Processing and Machine Learning Theory”, Academic Press, 2024 • Max A. Little: „Machine Learning for Signal Processing: Data Science, Algorithms, and Computational Statistics“, Oxford University Press, 2019

Microelectronic Systems (Master of Science)	
High Speed Digital Design (M9)	
Abbreviation	HSD / HSDL
Module responsibility	Prof. Dr.-Ing. Henning Mextorf
Duration / Semester/ Regular cycle	One semester / first or second semester / summer semester
Credits (CP) / Semester hours per week (SHW)	5 CP 2 + 2 SHW
Workload	Attendance: 60 h Self-study: 90 h
Type of module	Mandatory module
Prerequisites	none
Language	English
Learning outcomes	**Professional competence** • The students know the influence of the layout of structures on circuit boards on signal transit time and signal integrity • They understand the challenges when designing circuit boards for high-speed signals **Methodological competence** • The students are able to detect, analyze and evaluate problems in the area of high-speed circuit design and develop solutions • They are familiar with the use of electromagnetic field solvers and are capable of choosing the appropriate solver for particular problems **Social competence** • In a team effort, the students are able to define interfaces between subsystems and realize an overall system consisting of those subsystems
Learning content	**Lecture** • Introduction o Lumped and distributed elements on PCBs o Properties of trapezoid pulses o Overview on EM field solvers • Transients on transmission lines o Time domain transmission line equations (telegrapher equations) o Reflections from various terminations • Transmission lines o Microstripline o Stripline o Dielectric substrates o Coupled lines and crosstalk o Differential lines o Mixed-mode S-parameters • High speed logic

	○ Power consumption ○ Differential logic • Properties and modelling of other structures on PCBs ○ IC Packages ○ PCB Vias ○ Connectors • Design rules for PCB Layout ○ Single ended lines ○ Differential lines **Laboratory** • Project work: Electromagnetic field simulation, implementation and measurement of a transmission line structure.
Usability of the module	Master's degree program Microelectronic Systems Master's degree program Automatisierungstechnik
Requirements for recognition of credits (Study and exam requirements)	Typical examination types for module testing: Lecture: successful passing in written exam (K)(PL) Laboratory: successful participation in exercises (LA)(PVL) Further possible examination types: oral exam (M), presentation with paper (R). **Where more than one possible examination type is used in the module, the examination type to be used is to be made known by the responsible lecturer at the start of the course.**
Courses	HSD (Lecture) HSDL (Laboratory)
Type of Media	Blackboard, PowerPoint slides, computer simulations, interactive tools
Literature	In the current issue: • E. Bogatin, *Signal Integrity*, Prentice Hall, 2004 • S. H. Hall, G. W. Hall, J. A. McCall, *High Speed Digital System Design, A Handbook of Interconnect Theory and Design Practices*, John Wiley Sons, Inc., New York, 2000 • H. Johnson, M. Graham, *High-Speed Digital Design, A Handbook of Black Magic*, Prentice Hall, 1993 • M. I. Montrose, *Printed Circuit Board Design Techniques for EMC Compliance*, Wiley, 2000 • B. Young, *Digital Signal Integrity, Modeling and Simulation with Interconnects and Packages*, Prentice Hall, 2001 • S, C. Thierauf, *High-Speed Circuit Board Signal Integrity*, Artech House, 2004 • S. C. Thierauf, *Understanding Signal Integrity*, Artech House, 2011 • D. M. Pozar, *Microwave Engineering*, 4. Auflage, John Wiley & Sons, 2012

Microelectronic Systems (Master of Science)	
Sustainable Research Project 2 (M10)	
Abbreviation	SRP2
Module responsibility	Program coordinator FH Westküste (Prof. Dr. Henning Mextorf)
Duration / Semester/ Regular cycle	One semester / first or second semester / summer semester
Credits (CP) / Semester hours per week (SHW)	5 CP 1 SHW
Workload	Attendance: 15 h Self-study: 135 h
Type of module	Mandatory module
Prerequisites	Recommended: knowledge of fundamentals of scientific work and project management Sustainable research projects SRP1 and SRP2 can be taken and completed in any order and can be chosen as different subject specializations or be continued in the same specialization over two semesters.
Language	English
Learning outcomes	**Professional competence** The students • know the sustainable development goals and their relevance, • can apply in-depth knowledge and refined methods in their focus field. **Methodological competence** The students are able to • explore a subject of this Master's degree program at greater depth by finding literature and scientific publications and acquisition of the required theoretical and practical knowledge, • organize the given subject by applying methods of project management to achieve the goal in an efficient and effective manner, **Social competence** The students can • work on scientific problems in a team in a goal-oriented manner, • find technical and factual solutions to problems by discussing with representatives and non-specialists of the subject, • organize professional discussions in a goal-oriented and constructive manner. • take the different perspectives and interests of other participants into account, • deal with intercultural situations consciously and appropriately. **Self-competence** The students are capable of • developing and solving research and development questions specific to their area of specialization, considering limited resources (e.g. time, staff, tools) and aspects of sustainable development • manage themselves to fulfill tasks and complete the tasks by the scheduled deadline. • present subject-specific results plausibly in oral presentations or written reports and respond to questions professionally and

	appropriately.
Learning content	Students work in small groups on research-related project tasks relating to the topics of the Master's degree program. These are usually presented in a kick-off event by the university's research projects or, in individual cases, by cooperation partners from industry and research institutes who accompany the project and are subsequently selected by students. The small groups are each supervised by a professor in the development of the theoretical-scientific foundations, requirements analysis, concept development, implementation and evaluation. In a final conference, the small groups present their results in the form of short talks or poster presentations. The topic can be continued in the following semester or students can choose a new specialization.
Usability of the module	Master's degree program Microelectronic Systems Master's degree program Automatisierungstechnik
Requirements for recognition of credits (Study and exam requirements)	Typical examination types for module testing: Project: successful passing in presentation with paper (R) (SL) Further possible examination type: portfolio examination (PP). **Where more than one possible examination type is used in the module, the examination type to be used is to be made known by the responsible lecturer at the start of the course.**
Courses	SRP2 (small group project, KGP)
Type of Media	SRP2: (small group project, KGP) depending on chosen specialization: scientific publications, textbooks, datasheets and other literature, online resources, working independently in the project within a team
Literature	In current issue: • literature on scientific work, e.g.: Th. Deetjen, Published: a guide to literature review, outlining, experimenting, visualization, writing, editing, and peer review for your first scientific journal article, 2020 • literature on project management, e.g.: S.E.Portny, Project Management All-in-One, For Dummies, 2020 • literature on the chosen topic and specialization (recommended by supervising professor or as a result of students' literature study)

Microelectronic Systems (Master of Science)	
General Elective Module 2 (M11)	
Abbreviation	GEM2 / GEM2L
Module responsibility	Program coordinator FH Westküste (Prof. Dr. Henning Mextorf)
Duration / Semester/ Regular cycle	One semester / first or second semester / winter semester
Credits (CP) / Semester hours per week (SHW)	5 CP 2 + 2 SHW
Workload	Attendance: 60 h Self-study: 90 h
Type of module	Mandatory elective module
Prerequisites	Elective modules deal with in-depth or supplementary content of Microelectronic Systems at Master's level. Students receive a description of the elective modules for the coming semester and recommended prior knowledge before the start of each semester. In principle, it is also possible to apply for courses from other faculties, provided the necessary prior knowledge is available and there are free places.
Language	English, German
Learning outcomes	The compulsory elective module serves either to deepen and specialize in the field of microelectronic systems or to strengthen interdisciplinarity by choosing a topic outside the field. **Professional competence** Students can • deepen and specialize in the field of microelectronic systems or • strengthen interdisciplinarity by choosing a topic outside the field. • distinguish and understand key concepts, approaches and perspectives that are specific to the respective field **Methodological competence** Students are able to • transfer general scientific methods and solution approaches to problems in the field of application • evaluate specific solution approaches in the field of application with regard to their advantages and disadvantages and apply them accordingly • follow specialist discourses (e.g. at specialist conferences or in specialist journals or forums) and actively participate in them where appropriate **Social competence** The students are able to • work on problems in a team in a goal-oriented manner, • discuss technical and factual solutions to problems with representatives of the subject and non-specialists and to argue theoretically and methodically sound. • consider the different perspectives and interests of other participants appropriately,

	• deal with intercultural and interdisciplinary situations consciously and appropriately. **Self-competence** The students are able to • - work out concepts independently and acquire basic techniques or procedures in a new scientific field, • - manage themselves to fulfill tasks and complete the tasks by the scheduled deadline. • - present subject-specific results plausibly in oral presentations or written reports and respond to questions professionally and appropriately.
Learning content	The specific content of the module varies depending on the chosen course. The descriptions of the general elective modules are communicated to students before the start of each semester.
Usability of the module	Master's degree program Microelectronic Systems Master's degree program Automatisierungstechnik
Requirements for recognition of credits **(Study and exam requirements)**	Typical examination types for module testing: Lecture: successful passing in written exam (K)(PL) Laboratory: successful participation in exercises (LA)(PVL) Further possible examination types: oral exam (M), presentation with paper (R), portfolio (PP), Home and Project Work (HA), Examination-like Computer Applications (KC). **Where more than one possible examination type is used in the module, the examination type to be used is to be made known by the responsible lecturer at the start of the course.**
Courses	GEM2 (Seminar-style class) GEM2L (Laboratory)
Type of Media	GEM2: Tuition in seminars; blackboard, slides, computer simulation GEM2L: Practical course
Literature	See the description of the respective compulsory elective module

Microelectronic Systems (Master of Science)	
Master thesis and colloquium	
Abbreviation	MTH / MCO
Module responsibility	N.N.
Duration / Semester/ Regular cycle	One semester / third semester / summer or winter semester
Credits (CP) / Semester hours per week (SHW)	30 CP
Workload	Attendance: 0 h Self-study: 900 h
Type of module	Mandatory module
Prerequisites	At least 48 credit points earned.
Language	English
Learning outcomes	The students possess an advanced problem-solving competence by applying theory and methods of engineering to address theoretical, constructive, and/or experimental tasks in the field of microelectronic systems
Learning content	• Familiarization with the task through literature research and the creation of a work plan • Conducting and evaluating independent investigations • Discussing the results • Summarizing the findings in a scientific thesis • Presenting and defending the results in a colloquium
Usability of the module	Master’s degree program Microelectronic Systems
Requirements for recognition of credits (Study and exam requirements)	Master thesis and colloquium
Courses	N/A
Type of Media	N/A
Literature	Depending on the specific requirements of the master's thesis

Abbreviations

CP	Credit Point
HA	Home and Project Work (Haus- und Projektarbeit)
K	Examination (Klausur)
KC	Examination-like Computer Applications (Klausurähnliche Computeranwendungen)
KGP	Small Group Project (Kleingruppenprojekt)
Ko	Colloquium (Kolloquium)
LA	Laboratory Completion (Laborabschluss)
M	Oral Examination (Mündliche Prüfung)
N.N.	Name to be designated (nomen nominandum)
N/A	Not applicable
PL	Examination Performance (Prüfungsleistung)
PP	Portfolio Examination (Portfolio-Prüfung)
PVL	Preliminary Examination Performance (Prüfungsvorleistung)
R	Presentation (Referat)
SHW	Semester Hours per Week (Semesterwochenstunden)
SL	Academic Achievement (Studienleistung)