Fakultät Technik und Informatik
Department Informations- und Elektrotechnik

Module Handbook

for the
Master of Science degree course in
Information and Communications Engineering

11.07.2024
In the interest of non-discriminatory use of language, this Module Handbook alternates feminine and masculine pronouns.

Department of Information and Electrical Engineering
Hochschule für Angewandte Wissenschaften Hamburg
Berliner Tor 7 (building B)
20099 Hamburg

Tel. +49.40.428 75-8020
www.haw-hamburg.de

Contents

Assessment Types

According to § 14 APSO-INGI, as currently applicable, the assessment types for the following module handbook are defined as follows:

1. Written examination (Klausur / K)

A written examination is completed under supervision. Students must complete the set questions on their own, either without the use of study aids or with the use of specified study aids only. Written examinations last at least 60 and no longer than 240 minutes.

2. Colloquium (Kolloquium / KO)

A colloquium may be required as part of certain types of examination, or in combination with the Bachelor or Master thesis. A colloquium is an oral examination in which students must prove their knowledge of the material examined, speaking and responding freely in an open discussion. A colloquium lasts at least 15 and no more than 45 minutes, and is also aimed at establishing that the written work submitted was all the student's own work. Colloquia can be organised as individual or group examinations. The size of the group for group examinations should be considered accordingly when setting the length of the examination.

3. Lab work completion (Laborabschluss / LA)

Lab work is successfully completed when students have successfully conducted the experiments set by the examiner during the semester and have demonstrated their knowledge by taking part in corresponding colloquia and/or by submitting written records of their work and/or by completing set written tasks. Colloquia last for a minimum of 15 and a maximum of 45 minutes. The written work must be submitted by a deadline set by the examiner; the latest deadline is the end of the semester in whichthe class in question was taken.

4. Oral examination (Mündliche Prüfung / M)

In an oral examination, a student must demonstrate in discussion with the examiner that he or she fully understands the material on which he or she is being examined. Oral examinations generally last at least 15 and no more than 45 minutes. Oral examinations may be conducted as individual or group examinations, and are to be conducted by one examiner and one assessor in accordance with Section
An oral examination may alternatively be conducted by two or more examiners instead of one, i.e. by a panel of examiners; in such a case, the student is to be examined by one examiner only in each of the various examination subjects. Oral examinations are always assessed and graded by one examiner only, no matter whether they are conducted by several examiners or by an examiner and an assessor. The examiner responsible for grading in each case must consider the views of the other examiners/the assessor before deciding on the grade to be awarded. The main aspects covered in and results of each oral examination are to be recorded. The record is signed by the examiners and assessor and is filed with the examination documents.

5. Paper (Referat / R)

A paper is a presentation lasting between 15 and 45 minutes on the basis of written preparation by the student. A paper is followed by a discussion led by the student or tutor. Papers should not be read out from detailed notes; students should be able to speak spontaneously. Digital or hard copies of any presentations and graphics used are to be submitted to the examiner. The detailed written paper to be submitted to the examiner should summarise the key findings and conclusions.

6. Portfolio examination (Portfolio-Prüfung / PP)

A portfolio exam is a type of exam that consists of a maximum of ten exam items. At least two distinct types of examination should be used for the portfolio examination. The possible forms of examination that can be used result from the forms of examination mentioned in § 14 paragraph 3 APSO-INGI as well as from exercises during the semester. At the beginning of the course, the lecturer determines with which examination elements and with which weighting for the individual examination elements the portfolio examination is to take place. In the case of an examination performance, the individual examination elements lead to an overall grade for the respective portfolio examination according to their weighting. The overall scope of the portfolio test based on workload and degree of difficulty must not exceed the scope of the type of test if this were selected as the only test element.

Module descriptions

Information and Communications Engineering (Master of Science)	
Embedded Signal Processing	
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 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 small teams and in a goal-oriented manner, • take 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

Information and Communications Engineering (Master of Science)	
Smart Sensor Systems	
Abbreviation	SMS/SMSL
Module responsibility	Prof. Dr. Matthias Kronauge
Duration / Semester/ Regular cycle	One semester / first or second semester / winter or summer 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.: - acceleration - position (distance, angle) - velocity • algorithms for - sensor data processing - fusion of data from multiple sensors Methodological competence The students can • choose for a given task - an appropriate sensor type - 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 signal processing • developing and implementing 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.

Information and Communications Engineering (Master of Science)
Mandatory elective modules
In total 6 elective modules are mandatory: • 2 in the field of communications engineering: In the following listed as *Elective communications engineering 1* and *Elective communications engineer 2* Both are described with the content of an example module. More options for *Elective communications engineering 1 + 2* will be announced before the start of the semester. The order in which both modules are attended is not relevant. • 2 in the field of information engineering In the following listed as *Elective information engineering 1* and *Elective information engineering 2* Both are described with the content of an example module. More options for *Elective information engineering 1 + 2* will be announced before the start of the semester. The order in which both modules are attended is not relevant. • 2 general elective modules In the following listed as *General elective module 1* and *General elective module 2* with a detailed describtion of prerequisites, conditions, possible contents and goals. Specific modules will be announced before the start of the semester. The order in which both modules are attended is not relevant.

Information and Communications Engineering (Master of Science)	
Elective Communications Engineering 1 – Example: Wireless Systems	
Abbreviation	ECE1/ECE1L
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 elective module
Prerequisites	Recommended: Fundamentals of signals and systems (analog and digital) Fundamentals of digital signal processing Fundamentals of stochastics
Language	English
Learning outcomes	Professionell competences The students know (knowledge) • basic structures and properties of wireless systems and their components for: - Communication systems - Localization systems - Remote sensing systems • characteristics of mobile communication channels • basic principles of (digital) modulation schemes Methodological competences The students can (skills) • analyze and solve problems in the field of wireless systems • use MATLAB, Phyton or similar tools to simulate, design und parametrize wirless systems Self competences The students are capable of (competences) • analyzing a given problem in the field of wireless systems and develop and implement a solution taking performance, resource consumption and costs into account.
Learning content	Lecture: • working principles and structures of. - Communication systems - Localization systems - Remote sensing systems • Mobile communication channels • Modulation schemes Laboratory: • Simulation and/or realization of wireless systems • 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)	T Typical examination types for module testing: Seminar-style class: 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	ECE1 (Seminar-style class) ECE1L (Laboratory)
Type of Media	ECE1: Tuition in seminars; blackboard, slides, computer simulation ECE1L: Practical course
Literature	In current issue: • Proakis, J.; Salehi, M.: Digital Communications, McGraw-Hill Verlag • Kammeyer, K.-D.: Nachrichtenübertragung, Vieweg+Teubner Verlag • Oppenheim, A.; Schafer, R. (1986): Digital Signal Processing, Prentice Hall • Widrow, B.; Sterns, S.: Adaptive Signal Processing, Pearson Verlag • Manolakis, D.; Proakis, J.: Digital Signal Processing, Prentice Hall India • Mitra, S.: Digital Signal Processing: A Computer-Based Approach, McGraw-Hill Verlag • Skolnik, Merrill I.: Radar handbook, McGraw-Hill, New York

Information and Communications Engineering (Master of Science)	
Elective Communications Engineering 1 – Example: Distributed Systems and Applications	
Abbreviation	ECE1/ECE1L
Module responsibility	Prof. Dr.-Ing. Rainer Schoenen
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	Recommended: Programming in C, Computer/Communication Networks
Language	English
Learning outcomes	Professional competence The students know • methods for developing distributed and adaptive systems, • the communication between processes • tools for development Methodological competence The students are able/can • analyze theoretical models, e.g., Petri nets and queueing networks • implement communication in tightly and loosely coupled systems, • apply the skills in an individual project from planning to implemented app, • calculate and measure performance metrics in such systems, • acquire skills in an application domain, e.g., Smart Home, IoT, Cli/Server.
Learning content	• Tightly and loosely coupled systems, job processing systems, Petri nets. • Services and protocols of IP based communication networks. • Sockets, state machines, remote procedure calls, remote method invocation, distributed object systems, messages in coupled systems. • Programming, unit test and system test of coupled systems (tight/loose). • Project planning, scheduling, synchronization, coordination, exclusivity. • Optional: Components of adaptive systems, agents, fundamentals of game theory, auctions, graphical user interfaces, UNIX programming. Lab project work to apply the skills above.
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: Seminar-style class: 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	ECE1 (Seminar-style class) ECE1L (Laboratory)
Type of Media	ECE1: Tuition in seminars; blackboard, slides, computer simulation ECE1L: Practical course
Literature	In current issue: • Tanenbaum, A.S.: Computer networks, Pearson • Tanenbaum, A.S.: Distributed Systems: Principles and Paradigms • Wooldridge, M.: An Introduction to MultiAgent Systems, Wiley & Sons

Information and Communications Engineering (Master of Science)	
Elective Communications Engineering 2 – Example: Communication Networks	
Abbreviation	ECE2/ECE2L
Module responsibility	Prof. Dr. Kolja Eger
Duration / Semester/ Regular cycle	One semester / first or second semester / summer 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	Recommended: Computer Networks, Programming
Language	English
Learning outcomes	Methodological competence The students are able/can • analyze and relate principles of communication networks and network security • describe and evaluate how these are implemented in Internet protocols With the goal to understand how IP networks work (also in specific industrial domains) and to be able to develop distributed applications that are functional, secure, interoperable, scalable, efficient, and sustainable.
Learning content	• principles of networking (e.g. reliability, connection-orientation, congestion control, naming & addressing, forwarding & routing, link access, ...), • fundamentals and principles of network security (e.g. cryptography, protection goals, threats & attacks), • Internet protocols (e.g. TCP/IP, HTTP, TLS) and components & overlay networks (e.g. firewalls, Content Distribution Networks (CDN)), • advanced topics of computer networking (e.g. software-defined networking (SDN)), • Industrial networks (e.g. Smart Grid Communication).
Usability of the module	Master's degree program Information and Communications Engineering
Requirements for recognition of credits (Study and exam requirements)	Typical examination types for module testing: Seminar-style class: 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	ECE2 (Seminar-style class) ECE2L (Laboratory)
Type of Media	ECE2: Tuition in seminars; blackboard, slides, computer simulation ECE2L: Practical course

Literature	In current issue: • Computer Networking: a Top-Down Approach, Jim Korose and Keit Ross, Pearson • Cryptography and Network Security, principles and practice, William Stallings, Pearson • RFC documents: https://www.rfc-editor.org/

Information and Communications Engineering (Master of Science)	
Elective Communications Engineering 2 – Example: Radio Frequency Systems	
Abbreviation	ECE2/ECE2L
Module responsibility	Prof. Dr. Ralf Wendel
Duration / Semester/ Regular cycle	One semester / first or second semester / summer 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	Recommended: Communication and High Frequency Engineering, Electronics, Basics of Electromagnetic Field Theory
Language	English
Learning outcomes	Professional competence The students know • design assemblies such as oscillators, filters, mixers and antennas, • computer-aided design software for radio frequency (RF) components Methodological competence The students are able/can • design transmitters and receivers at high frequencies • set up RF-components, measure them and optimise the design by comparing measurements and calculations • use 3D field calculation- and RF simulation-software
Learning content	Seminar • Introduction to the design of an RF module, e.g. a radar module with typical assemblies for a transmitter and receiver in microstrip technology in the GHz range, e.g. design of small antennas for modern communication • Explanation of the design of assemblies such as oscillators, filters, mixers, antennas and introduction to computer-aided design using simulation tools • Subject to change due to current events Project • Self-dependent design based on a theoretical approach, construction and measurement of a module
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: Seminar-style class: 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	ECE2 (Seminar-style class) ECE2L (Laboratory)

Type of Media	ECE2: Tuition in seminars; blackboard, slides, computer simulation ECE2L: Practical course
Literature	In current issue: • Specific documents on the application of the software used • Specific practical training documents • Geißler, Kammerloher, Schneider: Calculation and Design Methods in High Frequency Technology Vol. 1+2, Vieweg Verlag • Pozar: Microwave Engineering, Wiley

Information and Communications Engineering (Master of Science)	
Elective Information Engineering 1 – Example: Security	
Abbreviation	EIE1/EIE1L
Module responsibility	Prof. Dr. Heike Neumann
Duration / Semester/ Regular cycle	One semester / first or second semester / summer 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	Recommended: Software Construction 1&2
Language	English
Learning outcomes	Professional competence The students are able/can • analyze digital systems with respect to their security objectives and security threats • design and implement suitable security measures to achieve security objectives • know the relevant standards for security measures and can apply them correctly in context Methodological competence The students are able/can • transfer general engineering methods and solution approaches (e.g. scientific work) to problems in the field of application • evaluate specific solution approaches in the field of application with respect to their advantages and disadvantages and apply them, for example, in the context of exercises • follow specialist discourses (e.g. at specialist conferences or in specialist journals or forums) and actively participate in them where appropriate Social skills (communication and cooperation) The students are able/can • take into account the interdisciplinary nature of the topic of safety and are able to explain the essential core tasks of the topic to non-specialists • present solutions they have developed themselves and be open to criticism and suggestions for improvement.
	Self-competence (scientific self-image, professionalism) Students are able/can • better assess the professional field and thus improve their career orientation.
Learning content	• Standards for security analysis of digital systems like *BSI's IT Grundschutz* • Concepts of Trusted Computing incl. *Secure Boot* and *Secure Execution* • Modern cryptographic security concepts like *Perfect Forward Secrecy* and *Zero Knowledge* for data protection

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: Seminar-style class: 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	EIE1 (Seminar-style class) EIE1L (Laboratory)
Type of Media	ESP: Tuition in seminars; blackboard, slides, computer simulation ESPL: Practical course
Literature	• A. J. Menezes, P. C. van Oorschot, and S. A. Vanstone *Handbook of Applied Cryptography* • C. Paar, J. Pelzl Understanding Cryptography: *A Textbook for Students and Practitioners* • G. Proudler, L. Chen, C. Dalton *Trusted Computing Platforms*

Information and Communications Engineering (Master of Science)	
Elective Information Engineering 1 Example: Safety of Critical Systems	
Abbreviation	EIE1/EIE1L
Module responsibility	Prof. Dr. Henning Dierks
Duration / Semester/ Regular cycle	One semester / first or second semester / summer 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	Recommended: Software Construction 1&2
Language	English
Learning outcomes	Professional competence The students are able/can • to model and analyse safety critical systems with respect to the requirements thereof • to choose appropriate state-of-the-art analysis techniques and apply them • know the limitations of the validation techniques Methodological competence The students are able/can • transfer general engineering methods and solution approaches (e.g. scientific work) to problems in the field of application • evaluate specific solution approaches in the field of application with respect to their advantages and disadvantages and apply them, for example, in the context of exercises • follow specialist discourses (e.g. at specialist conferences or in specialist journals or forums) and actively participate in them where appropriate Social skills (communication and cooperation) The students are able/can • take into account the interdisciplinary nature of the topic of safety and security and are able to explain the essential core tasks of the topic to non-specialists • present solutions they have developed themselves and be open to criticism and suggestions for improvement.
Learning content	• Architectural patterns for safety critical systems in domains like mobile systems, real-time systems, embedded systems. • Model-based development of safety critical systems • Methods of extended static checking • Application of both testing and verification methods
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: Seminar-style class: 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	EIE1 (Seminar-style class) EIE1L (Laboratory)
Type of Media	EIE1: Tuition in seminars; blackboard, slides, computer simulation EIE1L: Practical course
Literature	In current issue: • Pfleeger et al., Security in Computing, Pearson • Bozzano and Villafiorita, Design and Safety Assessment of Critical Systems, CRC Press • Olderog and Dierks, Real-Time Systems, Cambridge University Press

Information and Communications Engineering (Master of Science)	
Elective Information Engineering 2 – Example: Machine Learning and Neural Networks	
Abbreviation	EIE2/EIE2L
Module responsibility	Prof. Dr. Klaus Jünemann
Duration / Semester/ Regular cycle	One semester / first or second semester / summer 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	Recommended: Mathematics and programming at bachelor's degree level
Language	English
Learning outcomes	Professional competence The students are able/can • understand fundamental concepts of machine learning • understand the mathematics of the training process • construct, train, apply and evaluate neural networks and other machine learning models • can use machine learning concepts to develop innovative solutions in different application contexts • understand the design principles of the common machine learning frameworks • understand the challenges to deploy machine learning models to hardware platforms with constrained capabilities Methodological competence The students are able/can • transfer general engineering methods and solution approaches (e.g. scientific work) to problems in the field of application • evaluate specific solution approaches in the field of application with respect to their advantages and disadvantages and apply them, for example, in the context of exercises • follow specialist discourses (e.g. at specialist conferences or in specialist journals or forums) and actively participate in them where appropriate Social skills (communication and cooperation) The students are able/can ... • take into account the interdisciplinary nature of the topic of safety and are able to explain the essential core tasks of the topic to non-specialists • present solutions they have developed themselves and be open to criticism and suggestions for improvement.
Learning content	• Basics of machine learning: classification and regression, model evaluation, over- and underfitting, hyperparameter search • Linear models for regression: cost function, normal equations, regularization • Gradient descent: basic idea and algorithms, automatic differentiation, application to linear models • Softmax classification: probability model for classification, maximum likelihood estimation, cross entropy • Fully connected neural networks • Convolutional neural networks • Quantization of neural networks

	• Application of neural networks to image classification, audio analysis and signal processing
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: Seminar-style class: 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	ESP (Seminar-style class) ESPL (Laboratory)
Type of Media	ESP: Tuition in seminars; blackboard, slides, computer simulation ESPL: Practical course
Literature	In current issue: • C. Bishop: *Pattern Recognition and Machine Learning*, Springer • K. P. Murphy: *Probabilistic Machine Learning: An Introduction*, MIT Press • A. Zhang, Z.C. Lipton, M. Li, A.J. Smola: *Dive into Deep Learning*, Cambridge University Press • I. Goodfellow, Y. Bengio, A: Courville: Deep Learning, MIT Press

Information and Communications Engineering (Master of Science)	
Elective Information Engineering 2 – Example: System-on-Chip	
Abbreviation	EIE2 / EIE2L
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 elective 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 chip. • how systems on chip are put together from computer components and other digital and analog functional units. • the possibilities and criteria of dividing information technology problems into hardware and software domains. Methodological Competence The students can • design a System on Chip with regard to hardware and software requirements. • design systems and circuits and verify it using an advanced hardware description language (e.g. SystemVerilog). • Integrate HW-SW by hardware-related programming in a high-level programming language (e.g. C). • design a front-end on programmable logic (FPGA)
Learning content	Lecture • 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'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: Seminar-style class: 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	EIE2 (Seminar-style class) EIE2 L (Laboratory)
Type of Media	EIE2: Tuition in seminars; blackboard, slides, computer simulation EIE2L: 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/

Information and Communications Engineering (Master of Science)	
General Elective Module 1	
Abbreviation	GEM1 / GEM1L
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 elective module
Prerequisites	Elective modules deal with in-depth or supplementary content of Informations and Communications 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.
Language	English, German
Learning outcomes	The mandatory elective module serves either to deepen and specialize in the field of Information and Communications Engineering or to strengthen interdisciplinarity by choosing a topic outside the field. Professional competence The students can • deepen and specialize in the field of Information and Communications Engineering 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 The 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. • take into account 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: Seminar-style class: 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	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

Information and Communications Engineering (Master of Science)	
General Elective Module 2	
Abbreviation	GEM2 / GEM2L
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 elective module
Prerequisites	Elective modules deal with in-depth or supplementary content of Informations and Communications 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.
Language	English, German
Learning outcomes	The mandatory elective module serves either to deepen and specialize in the field of Information and Communications Engineering or to strengthen interdisciplinarity by choosing a topic outside the field. Professional competence The students can • deepen and specialize in the field of information and communications engineering 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 The 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. • take into account 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: Seminar-style class: 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	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

Information and Communications Engineering (Master of Science)	
Sustainable Research Project 1	
Abbreviation	SRP1
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)	Attendance: 17 h Self-study: 163h
Workload	Attendance: 9 h 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, at the request of student group: German (final presentation in Englisch)
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, taking into account 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)	Successful participation in the project with task completion and quality of results, presentation with paper (KGP) (R) or portfolio exam (PP).
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 ressources, 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)

Information and Communications Engineering (Master of Science)	
Sustainable Research Project 2	
Abbreviation	SRP2
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 1 SHW
Workload	Attendance: 17 h Self-study: 163h
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, at the request of student group: German (final presentation in Englisch)
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, taking into account 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)	Successful participation in the project with task completion and quality of results, presentation with paper (KGP) (R) or portfolio exam (PP).
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 ressources, 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)

Information and Communications Engineering (Master of Science)	
Master thesis and colloquium	
Abbreviation	MTH / MCO
Module responsibility	Chair of the Examinations Committee
Duration / Semester/ Regular cycle	One semester / third semester / winter and summer semester
Credits (CP) / Semester hours per week (SHW)	Master thesis: 27 CP Colloquium: 3 CP
Workload	Self-study: 900 h
Type of module	Mandatory Thesis
Prerequisites	Students may register the topic of their Master thesis once they have been awarded 50 CP in the program.
Language	English or German
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 information and communications engineering
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 Information and Communications Engineering
Requirements for recognition of credits (Study and exam requirements)	Regular examination type for module testing: Written thesis (27 CP) Colloquium (3 CP)
Courses	MTH (Master thesis) MCO (Master Colloquium)
Type of Media	MTH: independent scientific work
Literature	Depending on the specific requirements of the master's thesis