Modules handbook M.Sc. Functional Safety Engineering

Stand: 24.11.2022

Objectives

The master's degree program "Functional Safety Engineering" builds on a bachelor's degree as a second university degree. The master's program is aimed at graduates of a bachelor's degree in electrical engineering, computer science, mechatronics, or physics or builds on an equivalent degree and thus requires that comprehensive competencies in one of the fields mentioned above are already available at the beginning of the program.

In the master's program "Functional Safety Engineering," graduates acquire technical, methodological, and management skills to introduce and implement functional safety and reliability objectives in the corporate environment. The field of activity is to be seen here apart from the development of electronic and/or information-technical systems in ranges of Automotive, process industry, mechanical engineering, Mechatronic, Avionic, and medical technology as well as the entire spectrum of the producing trade as well as in service ranges.

In the curriculum of the master's program "Functional Safety Engineering," the modules on functional safety and reliability engineering represent the core qualification of the program. In addition, subject-related modules provide the required theoretical background knowledge, and interdisciplinary modules fulfill the interdisciplinary qualification requirements.
The project prescribed in the third semester allows theoretical knowledge of functional safety issues to be applied practically in a team and complex topics to be scrutinized and worked on.

In the master's thesis, students are expected to individually work on and solve comparable industrial or developmental situations and problems. The elective courses offered in the subject canon round off the targeted master's qualification with their technical in-depth knowledge transfer in selected subject areas.

The following objectives will be pursued:

- Sustained reinforcement and expansion of computer science/electrical engineering knowledge and skills related to technical and architectural requirements of reliability engineering and functional safety.
- Independent recognition and solution of complex problems in functional safety and reliability engineering.
- Deepening of methodical-analytical skills, particularly the ability to work on complex mathematical problems in functional safety and reliability engineering.
- Ability to carry out scientific work
- Preparation for taking over leading activities and demanding (development and research) tasks, especially in connection with Reliable and Functionally Safe Systems.
- Preparation for methodological and analytical requirements of different application conditions and areas in the entire spectrum of functional safety.
- Ability to analyze complex problems and select suitable solution methods and approaches.

- Ability to take an overall view of functional safety and reliability issues and to recognize interdisciplinary relationships.
- Competencies in written and oral presentations
- Independence, ability to work in a team, leadership qualification if necessary
- Willingness to critically reflect and take responsibility for the results of one's own work.

Intended learning outcomes

The master's degree program "Functional Safety Engineering" is designed to prepare graduates for managerial positions, demanding and complex development and research tasks, and high-performing graduates for a possible doctorate.
It is intended to introduce students to interdisciplinary ways of seeing and working and, as good preparation, to enable them to work in the entire spectrum of functional safety and its applications by acquiring skills in analyzing complex problems and selecting suitable methods.

In addition to the key technical competencies, presentation techniques, self-management, teamwork and project management, and in-depth knowledge of standards, and their legal implications, are taught as part of courses, seminars, and project work in the master's degree program "Functional Safety Engineering."
Furthermore, students should be enabled to apply methods and models appropriately and responsibly, quickly familiarize themselves with new related fields of application to take an overall view of systems' functional safety and reliability and recognize interdisciplinary relationships.

Students should be enabled to carry out case-by-case assessments of complex functional safety issues and to evaluate and solve them using methods and models of system analysis, probability considerations, and approximate mathematical model calculations concerning the underlying standards and technical regulations. Cost-benefit decisions and considerations in the design of functional safety systems must also be taken into account. In addition to technical and business considerations, knowledge of liability law resulting from the corresponding normative and legislative requirements must also be taken into account.

TABLE OF CONTENTS

1. COMPULSORY MODULES

ENGINEERING MATHEMATICS

Number/Code	<derzeit nicht verfügbar/verpflichtend>
Module name	**Engineering Mathematics**
Type of module	Compulsory
Learning outcomes, competencies, qualification goals	The student is able to: - derive and apply mathematical procedures, models, and methods - explain and evaluate the applicability of mathematical models to different system structures - find, derive, interpret and analyze different relevant safety parameters for application in functional safety and reliability assessment - apply and interpret different methodologies and concepts for mathematical derivation and determination. Learning results concerning the objectives of the course of study: They are gaining deeper insight into the mathematical and natural science areas. - Acquire in-depth knowledge of discrete and continuous distributions and their application. - Acquire in-depth knowledge of special distributions. - Acquire in-depth knowledge of special estimation techniques such as maximum likelihood estimation and their application. - Acquire in-depth knowledge of Markov chains and Markov models. - Acquire in-depth knowledge of probabilistic analysis methods. - Confident application and evaluation of the analytical methods described above in the mathematical modeling of systems.
Types of courses	6 SWS: 4 SWS Lecture 2 SWS Exercise
Course contents	Probability measure according to Kolmorgrov, random variables, Characteristics of distributions, discrete and continuous distribution functions, special distributions such as Weibull distribution in safety engineering, maximum likelihood estimation, parameter estimation, Bayesian methods, Taylor and McLaurin series and their application in safety engineering, mathematical calculation of function and reliability block diagrams, Markov chains, determination of reliability parameters using Markov models.
Course Title	**Engineering Mathematics**
Teaching and learning methods (forms of teaching and learning)	Lecture, presentation, learning by teaching, self-regulated learning, problem-based learning

Applicability of the module	Course of studies ECE, FUSE (Functional Safety Engineering) et. al.
Duration of the offer of the module	One semester
Frequency of the module offering	Winter semester
Language	English
Requirements for the participation in the module	none
Prerequisites for participation in the module	Prerequisites according to examination regulations
Student workload	240 h: 90 h attendance studies 150 h personal studies
Academic performances	None
Precondition for the admission to the examination performance	None
Examination performance	Written exams, 120-180 min. or oral exams, 20-40 min., or term papers, depending on the number of participants, will be announced in the first lecture.
Number of credits of the module	9 credits
In charge of the module	Prof. Dr. Dirk Dahlhaus
Teacher of the module	Prof. Dr. Dirk Dahlhaus and his co-workers
Forms of media	Projector, black board, paper
Literature references	- the literature will be announced in the course.

SOCIAL COMMUNICATION

Number/Code	<derzeit nicht verfügbar/verpflichtend>
Module name	**Social Communication**
Type of module	Compulsory
Learning results, competencies, qualification goals	The students are enabled to act communicatively in German in their everyday student life at the university and in daily situations outside the university and to participate in social daily life. They meet the linguistic requirements at level A1.1 of the Common European Framework of Reference for Languages (CEFR). As a result of the module, a linguistic basis is provided for social integration into the culture and life of studying in Germany. Students can use simple linguistic means to describe their own living conditions, activities, educational background and study experiences - in written and oral communication. They can also engage in simple social communication online. Within this spectrum, they acquire initial socio- and intercultural knowledge. -
Types of courses	4 SWS: face-to-face lessons with compulsory attendance, min. 75% 2 SWS: self-study units
Course contents	The learning content is based on the intended learning outcomes of the language level A1.1 and adapted for the requirements of everyday student life at the university. The following topics/focal points are among others: - Greetings/introductions in private and in university contexts, - talking about yourself and others and your family - making appointments/meetings, - talking about studies/schedule, - filling out forms and organising conversations in institutional contexts - Finding your way around the city, living and eating in Germany, - Peculiarities of the study culture in Germany, etc.
Title of the course	**Social Communication**
Teaching and learning methods (forms of teaching and learning)	Face-to-face seminar (4 units) with exercises and tasks, self-study units during the semester evaluated by the teacher to ensure individual learning success (2 units) and activity-based assignments for in-depth studying
Applicability of the module	Study programs: ECE, FUSE (Functional Safety Engineering) et. al.
Duration of the offer of the module	one Semester
Frequency of the module offering	Winter semester
Langugage	German

Recommended (content-related) prerequisites for participation in the module	none
Prerequisites for participation in the module	The module is designed exclusively for students of the FUSE and ECE degree programmes in the 1st semester without knowledge of the German language.
Student workload	180 h: 52 h face-to-face with compulsory attendance 26 h self-study units 102 h self-study
Academic performances	Exam (written and oral)
Precondition for the admission to the examination performance	Attendance in face-to-face classes min. 75 % Self-study units min. 75 %
Examination performance	Written exam 90 min. and oral exam 20 min.
Number of credits of the module	6 credits
In charge of the module	Dr. Bettina Baumgärtel/Dr. Marina Adams/Judith Labs, M.A.
Teacher of the module	NN
Forms of media	Moodle (self-study units, reference material)
Literature references	Textbook (study and work book), worksheets, digitalised tasks

INTRODUCTION TO SCIENTIFIC PUBLISHING

Number/Code	<derzeit nicht verfügbar/verpflichtend>
Module name	**Introduction to scientific publishing**
Type of module	Compulsory
Learning results, competencies, qualification goals	The learner can: - Apply basic subject-specific methods of information retrieval. - Develop and apply methodical procedures in a scientific environment. - Develop and apply methods of a scientific presentation. Learning outcomes related to program objectives: - Acquire in-depth knowledge of scientific work. - Acquire advanced and applied discipline-specific methods of information retrieval and information presentation. - Recognize and classify complex, interdisciplinary information representations. - Confident application and evaluation of analytical methods of information retrieval. - Independent development and evaluation of scientific solution methods. - Work and research in national and international contexts.
Types of courses	3 SWS (semester periods per week): 2 SWS lecture 1 SWS exercise
Course contents	
Title of the course	**Introduction to scientific work**
Teaching and learning methods (forms of teaching and learning)	Lecture, presentation, learning by teaching, self-regulated learning, problem-based learning
Applicability of the module	Study programs: ECE, FUSE (Functional Safety Engineering) et. al.
Duration of the offer of the module	one Semester
Frequency of the module offering	Winter semester
Langugage	English
Recommended (content-related) prerequisites for participation in the module	none
Prerequisites for participation in the module	none
Student workload	90 h: 35 h attendance studies 55 h self-studies
Academic performances	None

Precondition for the admission to the examination performance	None
Examination performance	Written exams, 120-180 min. or oral exams, 20-40 min., or term papers, depending on the number of participants, will be announced in the first lecture.
Number of credits of the module	3 credits
In charge of the module	Prof. Dr. Dirk Dahlhaus
Teacher of the module	Prof. Dr. Dirk Dahlhaus and co-workers
Forms of media	Projector, black board, paper
Literature references	- literature will be announced in the course.

INTRODUCTION TO INFORMATION THEORY AND CODING

Number/Code	<derzeit nicht verfügbar/verpflichtend>
Module name	**Introduction to information theory and coding**
Type of module	Compulsory
Learning results, competencies, qualification goals	- The student is able to: apply the basic knowledge of the information theory, - create and apply optimal and suboptimal procedures for the block and convolutional coding and decoding, - create and apply optimal and suboptimal procedures for source coding and decoding. Learning results with regard to the objectives of the course of study: - Gaining a deeper knowledge about the specific electrical fundamentals - Acquiring enhanced and applied subject-specific basics - Identifying and classifying complex electro-technical and interdisciplinary tasks - Being confident in the ability to use and evaluate analytical methods - Being able to create and evaluate solving methods independently - Gaining important and profound experience in the area of practical technical skills and engineering activities - Working and researching in national and international contexts
Types of courses	4 SWS (semester periods per week): 3 SWS lecture 1 SWS exercise
Course contents	- Fundamentals in information theory, entropy, mutual information - Typical sequences and Shannon capacity for the discrete memoryless channel - Channel coding: block codes, cyclic block codes, systematic form - Soft and hard decisions and performance; interleaving and code concatenation - Convolutional codes: tree and state diagrams, transfer function, distance properties; the Viterbi algorithm - Source coding: fixed-length and variable-length codes, Huffman coding; the Lempel-Ziv algorithm; coding for analog sources, rate-distortion function; pulse-code modulation; delta-modulation, model-based source coding, linear predictive coding (LPC)
Title of the course	**Introduction to information theory and coding**
Teaching and learning methods (forms of teaching and	Lecture, presentation, learning by teaching, self-regulated learning, problem-based learning

learning)	
Applicability of the module	Study programs: Functional Safety Engineering, Industrial Engineering, Mathematics, Electrical Engineering, ECE, Mechatronics, Vocational Education -Electrical Engineering, Computer Science
Duration of the offer of the module	one Semester
Frequency of the module offering	Winter semester
Langugage	English
Recommended (content-related) prerequisites for participation in the module	Introduction to Digital Communications
Prerequisites for participation in the module	Digital Communications I
Student workload	180 h: 70 h attendance studies 110 h personal studies
Academic performances	Practical training
Precondition for the admission to the examination performance	Practical training
Examination performance	Form of the examination: oral exam Duration of the examination: 30 min.
Number of credits of the module	6 Credits Lectures/ Exercise: 5, Practical training: 1
In charge of the module	Prof. Dr. Dirk Dahlhaus
Teacher of the module	Prof. Dr. Dirk Dahlhaus and co-workers
Forms of media	Projector, black board, piece of paper
Literature references	- T. Cover and J.A. Thomas, Elements of Information Theory, 2nd ed., Wiley, ISBN: 978 0 471 24195 9. - J.G. Proakis, Digital Communications, New York, NY: McGraw-Hill, 4th ed., 2001. - Papoulis, S. U. Pillai, Probability, Random Variables, and Stochastic Processes, McGraw-Hill, 4th ed., ISBN 0071226613.

Number/Code	<derzeit nicht verfügbar/verpflichtend>
Module name	**Introduction to functional safety**
Type of module	Compulsory
Learning results, competencies, qualification goals	The student will be able to: - Normative fixed architecture models of different safety standards (IEC61508, IEC62016, ISO26262, ISO13839). - Evaluate and assess. - Analyze and evaluate model properties of safety-related computer architectures. - Analyze and evaluate. - Derive and analyze reliability and safety parameters for different architecture models and analyze them. - Evaluate and assess diagnostic, test, and verification procedures for safety-related architectures and evaluate them. Learning outcomes related to program objectives: - Acquire in-depth knowledge of safety-related architectural models and structures. - Acquire in-depth knowledge of the analysis of safety-oriented architecture models for determining failure probabilities. - Acquire in-depth knowledge for the determination of reliability parameters of different safety-oriented architectures. - Acquire in-depth knowledge of special M-of-N-structures of safety engineering. - Acquire in-depth knowledge of diagnostic, testing, and test structures for architecture models in safety engineering systems.
Types of courses	4 SWS (semester periods per week): 2 SWS lecture 2 SWS exercise
Course contents	- Series and parallel structures as models and components of safety-related architectures and systems, - redundancy properties of different safety-related architecture models, - function block and Markov analysis of different safety-related architecture models, - M-of-N structures and their diagnostic possibilities, - analysis and calculation of different architecture models concerning hazard rate and PFD and PFH, diagnostic test and inspection methods of safety-related architecture models.
Title of the course	**Introduction to Functional Safety**
Teaching and learning methods (forms of teaching and learning)	Lecture, lecture, learning by teaching, self-directed learning, problem-based learning.

Applicability of the module	Study programs Functional Safety Engineering, Electrical Engineering, Mechatronics, Computer Science
Duration of the offer of the module	one Semester
Frequency of the module offering	Winter semester
Langugage	English
Recommended (content-related) prerequisites for participation in the module	None
Prerequisites for participation in the module	Prerequisites according to examination regulations
Student workload	180 h: 60 h attendance studies 120 h personal studies
Academic Performances	None
Precondition for the admission to the examination performance	None
Examination performance	Written exam (120 min.) or oral exam (40 min.), or term paper (15-20 pages), will be announced in the first lecture.
Number of credits of the module	6 Credits
In charge of the module	Prof. Dr. Josef Börcsök
Teacher of the module	Prof. Dr. Josef Börcsök and co-workers
Forms of media	Projector, black board, piece of paper Demonstration and design work on the PC
Literature references	- Barlow, R. E., Engineering Reliability, ASA.SIAM 1998, - Bitter, P., Technische Zuverlässigkeit, Springer 1977 - Leitch, R. D., Reliability Analysis for Engineers, Oxford Science Publication 1995, - Börcsök, J. Electronic Safety Systems, Hüthig 2004 - Neumann, P. Computer Related Risk, Addison Wesley 1995, - Goble, W., Evaluation Control Systems Reliability, ISA 1992, - Script (will be handed out at the beginning of the course), - Further literature will be announced in the course.

RISK DETERMINATION OF COMPUTER ARCHITECTURE

Number/Code	<derzeit nicht verfügbar/verpflichtend>
Module name	**Risk determination of Computer architectures**
Type of module	Selectable mandatory module
Learning results, competencies, qualification goals	The student will be able to: - Apply and evaluate different risk analysis methods. - Identify risks according to EN ISO 12100 (risk graph/risk matrix) and other safety standards. - Safety standards and assess them. - Identify and assess a specific risk. - Define appropriate safety functions to mitigate the risks accordingly. - Mitigate the risks accordingly. - Perform LOPA and HAZOP procedures to evaluate product and system safety issues. - Assess system safety issues. - Be able to use methods to avoid and control systemic risks when implementing safety functions. - And control systematic and random errors when implementing safety errors. - Determine the risk of different computer architectures, - identify potential risks in hardware and software components, - and apply methods to avoid and control systematic and random errors. - Select and combine suitable hardware structures to implement the previously defined safety function. - Provide evidence of the safety integrity achieved. Learning outcomes related to program objectives: - Acquire in-depth knowledge of different risk analysis Methods and their application. - Acquire advanced knowledge of architectural and structural risk reduction measures. - Acquire in-depth knowledge of the definition of a security function according to the risk to be protected. - Acquisition of comprehensive knowledge of the verification of safety-related parameters in connection with the risk assessment of a system. - Acquire in-depth knowledge of measures to control systematic and accidental risks of systematic and random errors for risk reduction. - Acquire and apply the means of verification of the achieved safety integrity achieved.
Types of courses	4 SWS (semester periods per week): 2 SWS lecture 2 SWS exercise
Course contents	Risk assessment (e.g. according to EN ISO 12100, IEC61508, EN620161

	etc.), analysis of a specific risk, HAZOP; FMEA, FTA, LOPA, probability theory, application of measures to control systematic and random errors, structure of safe computer architectures, mathematical model descriptions, calculation of safety-related parameters.
Title of the course	**Risk determination of Computer architectures**
Teaching and learning methods (forms of teaching and learning)	Lecture, presentation, learning by teaching, self-regulated learning, problem-based learning
Applicability of the module	Study programs: Functional Safety Engineering, Mechatronics, Computer Science
Duration of the offer of the module	one Semester
Frequency of the module offering	summer semester
Langugage	English
Recommended (content-related) prerequisites for participation in the module	Safety standards and norms of electronic systems, Functional Safety in computer architectures
Prerequisites for participation in the module	Prerequisites according to examination regulations
Student workload	180 h: 60 h attendance studies 120 h personal studies
Academic performances	None
Precondition for the admission to the examination performance	None
Examination performance	Written exam (60 - 180 min.), oral exam (20 - 40 min.), or term paper, depending on the number of participants, will be announced in the first lecture.
Number of credits of the module	- 6 credits, including 1 credit integrated key competence - Interdisciplinary studies: training of logical thinking, methodological competence Students have learned to work independently with safety standards. They can apply abstract basic principles to concrete case studies from the everyday environment.
In charge of the module	Prof. Dr. Börcsök
Teacher of the module	Prof. Dr. Börcsök and co-workers, Prof. Dr. Schepers
Forms of media	Projector, black board, piece of paper
Literature references	- Lecture notes (script) are going to be handed out at the beginning of the lecture. - Contents of the standards EN ISO 12100, EN ISO 13849, EN 62061, IEC 61508.

	- Neumann, P. Computer Related Risk, Addison Wesley 1995, - Leitch, R. D., Reliability Analysis for Engineers, Oxford Science Publication 1995, - More reference literature is going to be recommended in the course.

FUNCTIONAL SAFETY IN COMPUTER ARCHITECTURES

Number/Code	<derzeit nicht verfügbar/verpflichtend>

Module name	Functional Safety in computer architectures
Type of module	Selectable mandatory module
Learning results, competencies, qualification goals	The student will be able to: - Characteristics, basic concepts, relevant safety standards of computer systems' Functional safety and reliability Know and understand. - Derive and apply methods to increase the reliability of computer systems - Select a suitable hardware safety architecture and Derive an appropriate security concept from it. - Know qualitative and quantitative methods for analyzing the functional - Know qualitative and quantitative methods for analyzing computer systems' functional safety and reliability, and derive and apply them. Learning outcomes related to program objectives: - Acquire and apply in-depth knowledge of computer system characteristics, safety concepts, and corresponding standards relevant to functional safety standards. - Acquire and apply in-depth knowledge of models, methods, and structures to achieve specific "Safety Integrity Level" (SIL levels). - Acquire and apply in-depth knowledge of redundancy concepts. - Acquire and apply in-depth knowledge of fault tolerance methods. - Selection of suitable measures for the control of systematic and random errors. - Acquire and apply in-depth knowledge of qualitative and quantitative methods to consider functional safety.
Types of courses	4 SWS (semester periods per week): 2 SWS lecture 2 SWS exercise
Course contents	Characteristics, concepts of functional safety and reliability of computer systems, redundancy concepts, systematic and random errors, error handling in design and during operation, fault tolerance, reliability, safety concepts, qualitative and quantitative methods for the consideration of functional safety, reliability calculation, calculation of safety parameters
Title of the course	Functional Safety in computer architectures
Teaching and learning methods (forms of teaching and learning)	Lecture, presentation, learning by teaching, self-regulated learning, problem-based learning

Applicability of the module	Study program: Functional Safety Engineering
Duration of the offer of the module	one Semester
Frequency of the module offering	Summer semester
Langugage	English
Recommended (content-related) prerequisites for participation in the module	none
Prerequisites for participation in the module	Prerequisites according to examination regulations
Student workload	180 h: 60 h attendance studies 120 h personal studies
Academic performances	None
Precondition for the admission to the examination performance	None
Examination performance	Written exam 60 - 180 min., or oral 20 - 40 min. or term paper depending on number of participants, will be announced in the first lecture.
Number of credits of the module	- 6 credits, including 1 credit integrated key competence - Interdisciplinary studies: training of logical thinking, methodological competence Students have learned to work independently with safety standards. They can apply abstract basic principles to concrete case studies from the everyday environment.
In charge of the module	Prof. Dr. Josef Börcsök
Teacher of the module	Prof. Dr. Josef Börcsök and co-workers
Forms of media	Projector, black board, piece of paper
Literature references	- Lecture notes (script)/slides are going to be handed out at the beginning of the lecture. - Börcsök J., Electronic Safety Systems, Hüthig 2004 - Börcsök J., Functional Safety, Hüthig, 2006 - Leitch, R. D., Reliability Analysis for Engineers, Oxford Science Publication 1995, - Goble, W., Evaluation Control Systems Reliability, ISA 1992, - More reference literature is going to be recommended in the course.

INTRODUCTION TO SIGNAL DETECTION AND ESTIMATION

Number/Code	<derzeit nicht verfügbar/verpflichtend>
Module name	**Introduction to Signal Detection and Estimation**
Type of module	Selectable mandatory module
Learning results, competencies, qualification goals	- The student will able to: derive optimal and suboptimal statistic estimation techniques and to evaluate their quality - create a qualification procedure Learning results regarding the objectives of the course of study: - Gaining deeper insight into the mathematical and natural science areas - Gaining a deeper knowledge about the specific electrical fundamentals - Acquiring enhanced and applied subject-specific basics - Identifying and classifying complex electro-technical and interdisciplinary tasks - Being confident in the ability to apply and evaluate analytical methods - Being able to create and evaluate solving methods independently - Familiarising oneself with new areas of knowledge, running searches and assessing the results - Gaining important and profound experience in the area of practical technical skills and engineering activities - Working and researching in national and international contexts
Types of courses	4 SWS (semester periods per week): 3 SWS lecture 1 SWS exercise
Course contents	elements of hypothesis testing; mean-squared estimation covering the principle of orthogonality, normal equations, Wiener filters, related efficient numerical methods like Levinson-Durbin recursion, Kalman filters, adaptive filters; classification methods based on linear discriminants, kernel methods, support vector machines; maximum-likelihood parameter estimation, Cramer-Rao bound, EM algorithm
Title of the course	**Introduction to Signal Detection and Estimation**
Teaching and learning methods (forms of teaching and learning)	Lecture, presentation, learning by teaching, self-regulated learning, problem-based learning
Applicability of the module	Study program: Functional Safety Engineering, Electrical engineering, mechatronics, mathematics, computer science, ECE
Duration of the offer of the module	one Semester
Frequency of the module offering	Summer semester

Langugage	English
Recommended (content-related) prerequisites for participation in the module	Knowledge on basic principles about random variables
Prerequisites for participation in the module	Prerequisites according to examination regulations
Student workload	180 h: 60 h attendance studies 120 h personal studies
Academic performances	None
Precondition for the admission to the examination performance	None
Examination performance	Examination performance: oral examination (30 min.)
Number of credits of the module	6 credits and 2 credits of them apply to the integrated key competencies
In charge of the module	Prof. Dr. Dahlhaus
Teacher of the module	Prof. Dr. Dahlhaus and co-workers
Forms of media	Projector, black board, piece of paper
Literature references	- H. Vincent Poor, An Introduction to Signal Detection and Estimation, Springer, 2nd ed., ISBN 0-387-94173-8 or ISBN 3-540-94173-8. - Papoulis, S. U. Pillai, Probability, Random Variables, and Stochastic Processes, McGraw-Hill, 4th ed., ISBN 0071226613. - H.L. van Trees, Detection, Estimation, and Modulation Theory, vol. I, New York, NY: John Wiley & Sons, 1968.

PROGRAMMING LANGUAGES AND TECHNIQUES FOR SAFETY SYSTEMS

Number/Code	<derzeit nicht verfügbar/verpflichtend>
Module name	**PROGRAMMING LANGUAGES AND TECHNIQUES FOR SAFETY SYSTEMS**
Type of module	Compulsory
Learning results, competencies, qualification goals	The student will be able to: - Develop and test programs, function blocks and functions according to the international standard IEC 61131-3, - explain how the language elements work - Organize, classify and analyze program sequences using the IEC 61131-3 standard, - design, analyze and evaluate safety structures and monitoring functions - formally document and critically evaluate results. Learning outcomes related to program objectives: - Acquire in-depth knowledge of reliable programming structures. - Acquire in-depth knowledge of systematic development and verification of programs - Acquire in-depth knowledge of the analysis and evaluation of monitoring structures and diagnostic measures
Types of courses	4 SWS (semester periods per week): 2 SWS lecture 2 SWS exercise
Course contents	• Designing programmes as well as function blocks and models in a structured way according to the IEC 61131-3, by means of the function block diagram and the sequential function chart. • Applying language elements that are compliant with the standard IEC 61131-3. • Providing an introduction to the international standards.
Title of the course	**PROGRAMMING LANGUAGES AND TECHNIQUES FOR SAFETY SYSTEMS**
Teaching and learning methods (forms of teaching and learning)	Lecture, presentation, learning by teaching, self-regulated learning, problem-based learning
Applicability of the module	Study programs Functional Safety Engineering, Computer Science
Duration of the offer of the module	one Semester
Frequency of the module offering	Winter semester
Langugage	English
Recommended (content-related) prerequisites for participation in the module	none

Prerequisites for participation in the module	none
Student workload	180 h: 60 h attendance studies 120 h personal studies
Academic performances	2 documents/reports 6-10 pages in the pre-specified format
Precondition for the admission to the examination performance	None
Examination performance	Electronic exam (including programming task) 120-180 min.
Number of credits of the module	6 Credits
In charge of the module	Prof. Dr. Josef Börcsök
Teacher of the module	Dr. Michael Schwarz
Forms of media	Projector, black board, piece of paper, demonstrations, and design work at the PC
Literature references	- K.-H. John, M. Tiegelkamp, SPS-Programmierung nach IEC 61131-3, Springer Verlag 2000, - Günter Wellenreuther, Dieter Zastrow, Automatisieren mit SPS - Theorie und Praxis. Viegweg+Teubner, GMV Fachverlage GmbH, 2011, - Karl Pusch, Grundkurs IEC 1131, Vogel Fachbuch 1999, - Heinrich Lepers, SPS Programmierung nach IEC 61131-3 FranzisVerlag GmbH 2005, - More reference literature is going to be recommended in the course

METHODS FOR AUTOMATION FOR SAFETY RELATED SYSTEMS

Number/Code	<derzeit nicht verfügbar/verpflichtend>
Module name	**Methods for Automation for safety related Systems**
Type of module	Selectable mandatory module
Learning results, competencies, qualification goals	The student is able to: - Develop, realize and test procedures for modeling and programming, - create, test, and analyze technical procedures and methods for data communication, data backups, and data integrity for industrial communication, - design, organize, program, and implement the exchange of data between heterogeneous systems, - formally document and critically evaluate results. Learning results concerning the objectives of the course of study: - Acquire in-depth knowledge of conceptualizing data communications. - Acquire in-depth knowledge of data structures, data integrity, and data security. - Acquire in-depth knowledge of distributed communication structures and their data exchange.
Types of courses	4 SWS (semester periods per week): 2 SWS lecture 2 SWS exercise
Course contents	- The structured design of control programs and models according to the recognized SPS languages - Design, application, and evaluation of industrial communication networks - Design and implementation of procedures to assure data integrity in the automation technology - The structured design of architectures and distributed, disparate systems for the exchange of process data
Title of the course	**Methods for Automation for safety related Systems**
Teaching and learning methods (forms of teaching and learning)	Lecture, presentation, learning by teaching, self-regulated learning, problem-based learning
Applicability of the module	Study program: Functional Safety Engineering
Duration of the offer of the module	one Semester
Frequency of the module offering	summer semester
Langugage	English
Recommended (content-related) prerequisites for	none

participation in the module	
Prerequisites for participation in the module	Prerequisites according to examination regulations
Student workload	180 h: 60 h attendance studies 120 h personal studies
Academic performances	Academic performance: 2 documents/reports
Precondition for the admission to the examination performance	None
Examination performance	Examination: An electronic, written exam (incl. programming task) 120-180 min., oral 20-40 min., or term paper, depending on the number of participants, will be announced in the first lecture.
Number of credits of the module	6 credits, of which 1 credit integrated key competence Interdisciplinary studies: training of logical thinking, methodological competence Students have learned to work independently. They can apply abstract basic principles to concrete case studies from the everyday environment.
In charge of the module	Prof. Dr. Josef Börcsök
Teacher of the module	Dr. Michael Schwarz
Forms of media	Projector, blackboard, piece of paper, demonstrations, and design work at the PC
Literature references	- Günter Wellenreuther, Dieter Zastrow, Automatisieren mit SPS - Theorie und Praxis. Viegweg+Teubner, GMV Fachverlage GmbH, 2011, - Lange J., Burke T. J., Iwanitz F., OPC von Data Access bis Unified Architecture. 4 Ed. Berlin, VDE-Verl., 2010 - Schnell, Gerhard, Bussysteme in der Automatisierungs und Prozesstechnik Grundlagen, Systeme und Trends der industriellen Kommunikation, Vieweg, 2006 - Manfred Popp, Das PROFINET IO-Buch Grundlagen und Tipps für Anwender, Heidelberg : Hüthig, 2005 - Etschberger, K. Controller-Area-Network, München: Hanser, 2002 - Other literature will be announced in the lecture

SEMINAR

Number/Code	<derzeit nicht verfügbar/verpflichtend>
Module name	**Seminar**
Type of module	Compulsory
Learning results, competencies, qualification goals	The student is able to: - Apply the specialist knowledge acquired in the course of study to a defined task. - to a specified task in a problem-oriented manner, - to independently explore a topic from the literature, e.g., questioning statements, forming one's judgments, verifying statements, and opinions, verifying statements, consulting secondary literature, and synthesizing information from different sources. - Prepare scientific content for presentations in an understandable and structured for presentations, - use appropriate oral and written forms of - written forms of expression in scientific presentations.
Types of courses	4 SWS (semester periods per week): Seminar
Course contents	- Changing content depending on the topic
Title of the course	**Seminar**
Teaching and learning methods (forms of teaching and learning)	Independent processing and presentation of the seminar tasks with guidance from the lecturers.
Applicability of the module	Study Program: Functional Safety Engineering
Duration of the offer of the module	every Semester
Frequency of the module offering	Winter semester and summer semester
Langugage	English
Recommended (content-related) prerequisites for participation in the module	none
Prerequisites for participation in the module	Prerequisites according to examination regulations
Student workload	120 h
Academic performances	None
Precondition for the admission to the examination performance	None
Examination performance	Written paper (30-60 pages) and presentation (30-45 min.)
Number of credits	4 Credits

of the module	
In charge of the module	Prof. Dr. Josef Börcsök
Teacher of the module	All disciplines involved in the study program
Forms of media	
Literature references	Depending on the chosen topic

PROJECT

Number/Code	<derzeit nicht verfügbar/verpflichtend>
Module name	**Project**
Type of module	Compulsory
Learning results, competencies, qualification goals	- The student will be able to: - apply the specialized knowledge acquired in the course of study in a problem-oriented manner, - use the scientific methods taught in the course of study, and - analyze challenging problems and solve them independently and in cooperation with other students, - independently develop project planning, time management, and work within deadlines - Work within the project team on issues of work organization, conflicts, or the classification of their work in economic and social contexts and economic and social contexts and to work on them constructively. - (depending on the project chosen) acquire, if necessary, specifically required knowledge from the literature or through experiments, - and think in interdisciplinary contexts. - Design and implement new applications,
Types of courses	6 SWS Project
Course contents	Changing content depending on the topic
Title of the course	**Project**
Teaching and learning methods (forms of teaching and learning)	Independent processing of the assignment with guidance from the teachers
Applicability of the module	Study Program: Functional Safety Engineering
Duration of the offer of the module	every Semester
Frequency of the module offering	Winter semester and summer semester
Langugage	English
Recommended (content-related) prerequisites for participation in the module	none
Prerequisites for participation in the module	Prerequisites according to examination regulations
Student workload	240 h
Academic performances	None
Precondition for the	None

admission to the examination performance	
Examination performance	Written elaboration and presentation
Number of credits of the module	8 Credits
In charge of the module	Prof. Dr. J. Börcsök
Teacher of the module	All disciplines involved in the study program
Forms of media	
Literature references	- Depending on the chosen topic

MASTERMODUL

Number/Code	<derzeit nicht verfügbar/verpflichtend>
Module name	**Master's degree module**
Type of module	Compulsory
Learning results, competencies, qualification goals	The student will be able to: - apply the specialized knowledge acquired in the course of study in a problem-oriented manner, - use the scientific methods taught in the course of study, and - to independently develop and evaluate solution methods, - to familiarize oneself with new, also, interdisciplinary fields of knowledge and to evaluate the achieved results based on an independently developed project and time plan and within the period specified by the examination regulations - to solve a scientific and/or practice-oriented problem using scientific methods and knowledge - to document the methodology and the results of the master thesis in the clear and - to document and present the methodology and the results of the master thesis in a clear and comprehensible way, - to represent the results of the master thesis in a scientific discussion.
Types of courses	Master module
Course contents	- Changing engineering content in the field of safety and reliability engineering
Title of the course	**Master's degree module**
Teaching and learning methods (forms of teaching and learning)	Independent work on the assignment with minimal guidance from the instructor.
Applicability of the module	Study Program: Functional Safety Engineering
Duration of the offer of the module	
Frequency of the module offering	Every semester
Langugage	English
Recommended (content-related) prerequisites for participation in the module	All examinations are according to the examination regulations of the master's program in Functional Safety Engineering.
Prerequisites for participation in the module	Please refer to the examination regulations § 8 paragraph 1
Student workload	880 h

Academic performances	None
Precondition for the admission to the examination performance	Please refer to the examination regulations § 8 paragraph 1
Examination performance	Graded final thesis weighing three-fourths, presentation of the research work within the framework of a colloquium weighing one quarter
Number of credits of the module	30 credits and 6 credits of them apply to the integrated key competencies
In charge of the module	Prof. Dr. Josef Börcsök
Teacher of the module	All disciplines involved in the study program
Forms of media	
Literature references	- Depending on the chosen topic

2. FOCUS MODULES

SYSTEM AND CONTROL

ADVANCED DIGITAL CONTROL FOR FUNCTIONAL SAFETY SYSTEMS

Number/Code	<derzeit nicht verfügbar/verpflichtend>
Module name	**Advanced Digital Control for Functional Safety Systems**
Type of module	Compulsory
Learning results, competencies, qualification goals	The student will be able to: - analyze, model, and evaluate processes - develop, evaluate and test open and closed control algorithms in models and programs - Validate and verify software modules. - Formally document and critically evaluate results - independently present topics from the practical part in written scientific form. Learning outcomes related to program objectives: - Acquire in-depth knowledge of process modeling. - Acquisition of in-depth knowledge and methods of discretization and digitization - Acquire in-depth knowledge of designing, validating, and verifying software modules. - To prepare, display and present results scientifically.
Types of courses	4 SWS (semester periods per week): 2 SWS lecture 2 SWS exercise
Course contents	• The structured design of digital control algorithms • Modeling and analysis of industrial processes • Methods for validation and verification of modules. • Conversion of time-continuous processes and procedures into digital, process computer-aided methods
Title of the course	**Advanced Digital Control for Functional Safety Systems**
Teaching and learning methods (forms of teaching and learning)	Lecture, presentation, learning by teaching, self-regulated learning, problem-based learning
Applicability of the module	Study program Functional Safety Engineering
Duration of the offer of the module	one Semester
Frequency of the module offering	Winter semester
Langugage	English
Recommended (content-	none

related) prerequisites for participation in the module	
Prerequisites for participation in the module	Prerequisites according to examination regulations
Student workload	180 h: 60 h attendance studies 120 h personal studies
Academic performances	2 documents/reports
Precondition for the admission to the examination performance	None
Examination performance	Examination: Electronic exam (incl. programming task) 120-180 min. or oral, 20-40 minutes, depending on the number of participants, will be announced in the first lecture.
Number of credits of the module	6 credits, of which 1 credit integrated key competence Students are able to independently research the contents of the internship on a general level as well as to present a corresponding topic in scientific form or to adequately present it in written form.
In charge of the module	Prof. Dr. Josef Börcsök
Teacher of the module	Dr. Michael Schwarz
Forms of media	Projector, black board, piece of paper, demonstrations, and design work at the PC
Literature references	- Günter Wellenreuther, Dieter Zastrow, Automatisieren mit SPS - Theorie und Praxis. Viegweg+Teubner, GMV Fachverlage GmbH, 2011, - L. Litz, Grundlagen der Automatisierungstechnik, Oldenburg Wissenschaftsverlag GmbH 2005, - Åström, Karl J. ; Hägglund, Tore, PID controllers, Research Triangle Park, NC : Instrument Soc. of America, 1995 - Grimble M. Robust Industrial Control Systems. Wiley, 2006 - Landau, I. D. ; Zito, G. Digital control systems design, identification and implementation, London : Springer, 2006 - further literature will be announced in the course.

COMPUTER BASED DESIGN OF MICROELECTRONIC CIRCUITS

Number/Code	<derzeit nicht verfügbar/verpflichtend>
Module name	**Computer Based Design of Microelectronic Circuits**
Type of module	Selectable mandatory module
Learning results, competencies, qualification goals	The student will able to: - sketch out the process and targets of the physical design, - explain predetermined, well-known algorithms, - combine partial algorithm sections in a way that they form a complete process, compare implementations of given algorithms, - create implementations of algorithms, - assess in qualitative terms the results of placement and wiring, - classify and explain simulation procedures Learning results concerning the objectives of the course of study: - Gaining more profound insight into the mathematical and natural science areas - Achieving a deeper knowledge of the specific electrical fundamentals - Acquiring enhanced and applied subject-specific basics - Identifying and classifying complex electro-technical and interdisciplinary tasks - Being confident in the ability to use and evaluate analytical methods - Being able to create and assess solving strategies independently - Familiarising oneself with new areas of knowledge, running searches, and evaluating the results - Gaining significant and profound experience in the area of practical technical skills and engineering activities - Working and researching in national and international contexts
Types of courses	3 SWS (semester periods per week): 2 SWS lecture 1 SWS exercise
Course contents	Based on the theoretical foundations, methods and algorithms, which provide the basis for current industrial CAD systems for the integrated circuit design (chip design), are discussed in a way following the corresponding design process. This promotes a deeper understanding of their functionality and thus enables an efficient and targeted use of these tools. Among other things, this course deals with optimization methods, algorithms of physical design (partitioning, placement, and wiring), and simulation algorithms.
Title of the course	**Computer based Design of microelectronic Circuits**
Teaching and learning methods (forms of teaching and	Lecture, presentation, learning by teaching, self-regulated learning, problem-based learning

learning)	
Applicability of the module	Study programs: Electrical engineering, mechatronics, computer science, Functional Safety Engineering
Duration of the offer of the module	one Semester
Frequency of the module offering	Summer semester
Langugage	German, English is also possible after prior consultation
Recommended (content-related) prerequisites for participation in the module	Knowledge of discrete mathematics
Prerequisites for participation in the module	Prerequisites according to examination regulations
Student workload	180 h: 45 h attendance studies 135 h personal studies
Academic performances	none
Precondition for the admission to the examination performance	None
Examination performance	Written exam (90 min.) or oral exam (approx. 40 min.)
Number of credits of the module	6 credits
In charge of the module	Prof. Dr. Peter Zipf
Teacher of the module	Prof. Dr. Peter Zipf and co-workers
Forms of media	Slides, projector, blackboard
Literature references	- Sabih H. Gerez: Algorithms for VLSI Design Automation, John Wiley & Sons, 1. Auflage, 1998 - Naveed A. Sherwani: Algorithms for VLSI Physical Design Automation, Springer Verlag; 3. Auflage. 1999 - Michael J. S. Smith: Application-Specific Integrated Circuits, Addison-Wesley Longman, 1997 - Jens Lienig: Layoutsynthese elektronischer Schaltungen, Springer Verlag, 1. Auflage, 2006 - Reinhard Diestel: Graphentheorie, Springer, Berlin; 3. Auflage, 2006 - Further literature will be announced in the course.

PROCESS COMPUTING

Number/Code	<derzeit nicht verfügbar/verpflichtend>
Module name	**Process computing**
Type of module	Selectable mandatory module
Learning results, competencies, qualification goals	The student will be able to: - Describe the structure of processes and classify different classifications. - Know and describe the structure and mode of operation of the components of a process computer system and describe them. - Know, classify, derive and apply the mathematical description of Classify, derive, and apply mathematical descriptions of control and regulation processes. - Describe the structure and function of peripheral units (sensors/actuators) and their use. - Classify and evaluate hardware and software components and derive control options using process computers. - Evaluate and classify the real-time behavior of the processes to be controlled and regulated. - Derive and apply the calculation of reliability-related parameters of process computer systems. Learning outcomes related to program objectives: - Acquire and apply in-depth knowledge of process computer and automation systems. - Acquire and apply in-depth knowledge of the function of peripheral units in process computer systems. - Recognize and classify the real-time characteristics of process computer systems. - Apply and evaluate calculations on the reliability and technical parameters of process computer systems. - Recognition and classification of complex interdisciplinary process-technical tasks and the reliable application and analytical methods to assess reliability.
Types of courses	4 SWS (semester periods per week): 2 SWS lecture 2 SWS exercise
Course contents	Structures of processes, mathematical model descriptions, the structure of process computer and automation systems, design and principle of operation of peripheral units, real-time properties programming and tool selection, the introduction of the standard systems available on the market today, and tools concerning the application, Examples of applications coming from various applications
Title of the course	**Process computing**
Teaching and learning methods (forms of teaching and learning)	Lecture, presentation, learning by teaching, self-regulated learning, problem-based learning

Applicability of the module	Study programs: Functional Safety Engineering, Mechanical Engineering, Industrial Engineering, Electrical Engineering, Vocational Education-Electrical Engineering, Computer Science, Mechatronics
Duration of the offer of the module	one Semester
Frequency of the module offering	Summer semester
Langugage	English
Recommended (content-related) prerequisites for participation in the module	none
Prerequisites for participation in the module	Prerequisites according to examination regulations
Student workload	180 h: 60 h attendance studies 120 h personal studies
Academic performances	
Precondition for the admission to the examination performance	None
Examination performance	Written exam, 120 min. or oral exam, 40 min. or term paper, depending on the number of participants, will be announced in the first lecture.
Number of credits of the module	6 credits, including 1 credit of integrated key competency - Interdisciplinary Studies: students recognize reciprocal relationships of different application areas of Functional Safety in Medicine and Law.
In charge of the module	Prof. Dr. Josef Börcsök
Teacher of the module	Prof. Dr. Josef Börcsök and co-workers
Forms of media	Projector, black board, piece of paper, demonstrations, and design work at the PC
Literature references	- Heidepriem, Prozessinformatik 1, Oldenburg 2000 - Heidepriem, Prozessinformatik 2 , Oldenburg 2001 - Lauber, R., Prozessautomatisierung, Springer 1989 - Färber, G. Prozessrechentechnik, Springer 1994 - Börcsök, J. Prozessrechner und Automation, Heise 1999 - further literature will be announced in the course.

RECONFIGURABLE STRUCTURES

Number/Code	<derzeit nicht verfügbar/verpflichtend>
Module name	**Reconfigurable Structures**
Type of module	Selectable mandatory module
Learning results, competencies, qualification goals	The student is able to: - outline the basic structure of FPGAs, - explain the methods for placing and wiring as well as their contexts, - give reasons for the quantitative architecture decisions, - describe and evaluate different architectural models and reconfiguration processes, - develop proposals for the architecture, - explain the procedures of dynamic reconfiguration, - assess the possible field of application of the FPGAs. Learning results concerning the objectives of the course of study: - Gaining more profound insight into the mathematical and natural science areas - Achieving a deeper knowledge of the specific electrical fundamentals - Acquiring enhanced and applied subject-specific basics - Identifying and classifying complex electro-technical and interdisciplinary tasks - Being confident in the ability to apply and evaluate analytical methods - Being able to create and evaluate solving methods independently - Familiarising oneself with new areas of knowledge, running searches, and assessing the results - Gaining significant and profound experience in the area of practical technical skills and engineering activities - Working and researching in national and international contexts
Types of courses	4 SWS (semester periods per week): 2 SWS lecture 2 SWS exercise
Course contents	Way of operation and inner structure of FPGAs and other reconfigurable or structurally programmable circuits. Initially, it is dealt with FPGAs and the basics of the software tools that are required to program them and it is also dealt with the corresponding optimisation goals and methods. On this basis, further coarse-grained and fine-grained architectures and techniques of the dynamic reconfiguration are going to be discussed. Furthermore, the basics are provided that enable the student to include reconfigurable architectural elements and reconfiguration concepts to chip and circuit design projects as they are currently needed in many companies.
Title of the course	**Reconfigurable Structures**
Teaching and learning	Lecture, presentation, learning by teaching, self-regulated learning,

methods (forms of teaching and learning)	problem-based learning
Applicability of the module	Study programs: Functional Safety Engineering, Mechatronics, Electrical Engineering, Computer Science
Duration of the offer of the module	one Semester
Frequency of the module offering	Summer semester
Langugage	German, English is also possible after prior consultation
Recommended (content-related) prerequisites for participation in the module	Knowledge of digital circuit design (undergraduate level), algorithms & data structures (undergraduate level), and discrete mathematics (basic).
Prerequisites for participation in the module	Prerequisites according to examination regulations
Student workload	180 h: 60 h attendance studies 120 h personal studies
Academic performances	2 documents/reports
Precondition for the admission to the examination performance	None
Examination performance	Oral exam (approx. 40 min.) or term paper including a presentation
Number of credits of the module	6 credits
In charge of the module	Prof. Dr. Peter Zipf
Teacher of the module	Prof. Dr. Peter Zipf and co-workers
Forms of media	Slides, beamer, blackboard, computer exercise
Literature references	- Scott Hauck, Andre DeHon (Hrsg.): Reconfigurable Computing: The Theory and Practice of FPGA-Based Computation, Morgan Kaufmann Series in Systems on Silicon, Academic Press, 2007 - Vaughn Betz, Alexander Marquardt, Jonathan Rose: Architecture and CAD for Deep-Submicron FPGAs, Springer Verlag, 1999 - Dimitrios Soudris, Stamatis Vassiliadis (Hrsg.): Fine- and Coarse-Grain Reconfigurable Computing, Springer-Verlag, 2007 - Ramachandran Vaidyanathan, Jerry Trahan: Dynamic Reconfiguration: Architectures and Algorithms (Series in Computer Science), Springer Netherlands, 2003 - further literature will be announced in the course.

Number/Code	<derzeit nicht verfügbar/verpflichtend>
Module name	**Verification of embedded systems**
Type of module	Selectable mandatory module
Learning results, competencies, qualification goals	The student is able to: - define data flow analyses for imperative programs independently, - explain the fundamentals of abstract interpretation (partial orders, Galois relations, abstract transformers), - apply static programs analyses to programs with pointers, - use static program analyses to estimate the runtimes of embedded systems. Learning results concerning the objectives of the course of study: - Gaining deeper insight into the mathematical and natural science areas - Gaining a deeper knowledge of the specific electrical fundamentals - Acquiring enhanced and applied subject-specific basics - Identifying and classifying complex electro-technical and interdisciplinary tasks - Being confident in the ability to apply and evaluate analytical methods - Being able to create and evaluate solving methods independently - Familiarising oneself with new areas of knowledge, running searches, and assessing the results - Gaining important and profound experience in the area of practical technical skills and engineering activities - Working and researching in national and international contexts
Types of courses	4 SWS
Course contents	• Real-time systems: Timed Automata, Region Graph, Zone Graph, Timed CTL, Timed Bisimulation, Uppaal • Probabilistic Systems: Markov Chains, Markov Decision Processes, Probabilistic CTL, Probabilistic Bisimulation, Prism • Hybrid Systems: Differential Equations, Hybrid Automata, Linear Hybrid Automata, Selected Model Checking Tools
Title of the course	**Verification of embedded systems**
Teaching and learning methods (forms of teaching and learning)	Lecture, presentation, learning by teaching, self-regulated learning, problem-based learning
Applicability of the module	Study program Functional Safety Engineering, Information Technology
Duration of the offer of the module	one Semester

Frequency of the module offering	Summer semester
Langugage	English
Recommended (content-related) prerequisites for participation in the module	Theoretical computer science I + II, introduction to formal verification; basic knowledge of stochastics.
Prerequisites for participation in the module	Prerequisites according to examination regulations
Student workload	180 h: 60 h attendance studies 120 h personal studies
Academic performances	None
Precondition for the admission to the examination performance	None
Examination performance	oral exam (30 min.) / written exam (90 min) / term paper, depending on the number of participants
Number of credits of the module	6 credits
In charge of the module	Prof. Dr. Martin Lange
Teacher of the module	Prof. Dr. Martin Lange and co-workers
Forms of media	Projector, black board, piece of paper
Literature references	- Lecture slides - C. Baier, J.-P. Katoen. Principles of Model Checking, MIT Press, 2008 - other recent research articles will be announced in the lecture

MATHEMATICAL MODELS AND SOFTWARE TECHNOLOGY

COMMUNICATION TECHNOLOGIES 1

Number/Code	<derzeit nicht verfügbar/verpflichtend>
Module name	**Communication Technologies 1**
Type of module	Selectable mandatory module
Learning results, competencies, qualification goals	The learner will be able to investigate and question advanced and current topics in the areas of machine learning and data mining.
Types of courses	4 SWS: 2 SWS lecture 2 SWS exercise
Course contents	Machine Learning I: Algorithms for Context / Activity Recognition • Advanced and current topics in machine learning and data mining • Application of machine learning algorithms, e.g.: o Introduction to Activity / Context Recognition / Emotion Recognition o Preprocessing: Time Series Segmentation Algorithms o Feature Extraction o Bayesian Classification o Decision Trees o Hidden Markov Models o KNN / Clustering o Neural Networks I: Multilayer Perceptrons / Backpropagation • Introduction to writing scientific papers • Writing scientific papers and presentations, as well as programming
Title of the course	**Communication Technologies 1**
Teaching and learning methods (forms of teaching and learning)	Lecture, presentation, learning by teaching, self-regulated learning, problem-based learning
Applicability of the module	Study program Functional Safety Engineering, Electrical engineering , Information Technology
Duration of the offer of the module	one Semester
Frequency of the module offering	winter semester
Langugage	Bilingual (English or German by arrangement)
Recommended (content-related) prerequisites for participation in the module	Mobile Computing
Prerequisites for participation in the module	none

Student workload	180 h: 60 h attendance studies 120 h personal studies
Academic performances	regular work on exercises
Precondition for the admission to the examination performance	None
Examination performance	Course achievements (b/nb): oral presentation, report Examination performance: oral examination or written examination (30 or 120 min.)
Number of credits of the module	6 credits
In charge of the module	Prof. Dr. Klaus David
Teacher of the module	Prof. Dr. Klaus David and co-workers
Forms of media	Script, slides for download, exercises, software demonstrations, own handling of real products/software
Literature references	- Lecture slides - "Data Mining - Practical Machine Learning Tools and Techniques (4th edition)", Ian H. Witten, Eibe Frank, Mark A. Hall, Christopher J. Pal, Elsevier, 2017 - "Pattern Recognition and Machine Learning", Christopher M. Bishop, Springer, 2006 - "Machine Learning", Peter Flach, Cambridge University Press, 2012 - "Artificial Intelligence - A Modern Approach", Stuart J Russel and Peter Norvig, Prentice Hall, 2016 - "The Elements of Statistical Learning", Trevor Hastie, Robert Tibshirani, Jerome Friedman, Springer, 2009 - Additional literature will be announced in lecture.

COMMUNICATION TECHNOLOGIES 2

Number/Code	<derzeit nicht verfügbar/verpflichtend>

Module name	Communication Technologies 2
Type of module	Selectable mandatory module
Learning results, competencies, qualification goals	The learner will be able to investigate and question advanced and current topics in the areas of machine learning and data mining.
Types of courses	4 SWS: 2 SWS lecture 2 SWS exercise
Course contents	Machine Learning II: Applications and Algorithms for Context / Activity Recognition • Advanced and current topics in machine learning and data mining • Application of machine learning algorithms, e.g. o Activity Recognition II: Evaluation metrics / Instance-based vs. pattern-based evaluation o Time Series Segmentation Algorithms o Alignment Algorithms for Context Prediction o Bayesian Filtering o Gaussian Mixture Models o Home Automation o Neural Networks II: Deep Learning / Convolutional Neural Networks • Introduction to writing scientific papers Writing of scientific papers and presentations, as well as programming
Title of the course	Communication Technologies 2
Teaching and learning methods (forms of teaching and learning)	Lecture, presentation, learning by teaching, self-regulated learning, problem-based learning
Applicability of the module	Study programs: ECS, FUSE (Functional Safety Engineering), Electrical Engineering, Computer Science
Duration of the offer of the module	one Semester
Frequency of the module offering	winter semester
Langugage	Bilingual (English or German by arrangement)
Recommended (content-related) prerequisites for participation in the module	none
Prerequisites for participation in the module	none
Student workload	180 h: 60 h attendance studies 120 h personal studies
Academic performances	regular work on exercises

Precondition for the admission to the examination performance	None
Examination performance	Course achievements (b/nb): oral presentation, report Examination performance: oral examination or written examination (30 or 120 min.)
Number of credits of the module	6 credits
In charge of the module	Prof. Dr. Klaus David
Teacher of the module	Prof. Dr. Klaus David and co-workers
Forms of media	Presentation with beamer, computer exercises, paper exercises
Literature references	- Lecture slides - "Data Mining - Practical Machine Learning Tools and Techniques (4th edition)", Ian H. Witten, Eibe Frank, Mark A. Hall, Christopher J. Pal, Elsevier, 2017 - "Pattern Recognition and Machine Learning", Christopher M. Bishop, Springer, 2006 - "Machine Learning", Peter Flach, Cambridge University Press, 2012 - "Artificial Intelligence - A Modern Approach", Stuart J Russel and Peter Norvig, Prentice Hall, 2016 - "The Elements of Statistical Learning", Trevor Hastie, Robert Tibshirani, Jerome Friedman, Springer, 2009 - Additional literature will be announced in lecture.

Number/Code	<derzeit nicht verfügbar/verpflichtend>
Module name	**Pattern Recognition II**
Type of module	Selectable mandatory module
Learning results, competencies, qualification goals	The student will able to: - explain different tasks, models, and algorithms of pattern recognition, - develop new modeling approaches for classification and regression problems, - plan and implement new applications independently, - critically analyze, compare and evaluate existing methods and applications. Learning outcomes related to program objectives: - Acquire in-depth knowledge in the area of data-driven modeling of uncertainty and risk using probabilistic methods. - Acquire advanced and applied domain-specific fundamentals in classification and regression with functional safety and reliability applications. - Confidently apply and evaluate pattern recognition methods. - Independently develop and evaluate solutions, applications, and results based on pattern recognition methods in the area of functional safety and reliability. - Basic skills on scientific discussions in the field of pattern recognition.
Types of courses	4 SWS (semester periods per week): 3 SWS lecture 1 SWS exercise
Course contents	The lecture deals with the basics and methods of pattern recognition, especially from a probabilistic point of view. The following topics will be discussed: Fundamentals (including stochasticity, model selection, the curse of dimensionality, decision and information theory), distributions (including multinomial, Dirichlet, Gaussian and Student distributions, nonparametric estimation), linear models for regression, linear models for classification, mixed models and expectation maximization, statistical learning theory (support vector machines), example applications (online clustering, anomaly detection, etc.).
Title of the course	**Pattern Recognition II**
Teaching and learning methods (forms of teaching and learning)	Lecture, presentation, learning by teaching, self-regulated learning, problem-based learning
Applicability of the module	Study programs: Functional Safety Engineering, Electrical Engineering, Mechanical Engineering, Mechatronics, Computer Science, Mathematics
Duration of the offer of the module	one Semester
Frequency of the module	Winter semester

offering	
Langugage	Bilingual (English or German by arrangement)
Recommended (content-related) prerequisites for participation in the module	Basic knowledge of stochastics, analysis, and linear algebra
Prerequisites for participation in the module	none
Student workload	180 h: 60 h attendance studies 120 h personal studies
Academic performances	regular work on exercises
Precondition for the admission to the examination performance	None
Examination performance	mündliche Prüfung (20 Min.)
Number of credits of the module	6 credits
In charge of the module	Prof. Dr. Sick
Teacher of the module	Prof. Dr. Sick and co-workers
Forms of media	Presentation with beamer, computer exercises, paper exercises
Literature references	- Lecture slides, - various chapters of the book Christopher M. Bishop: Pattern Recognition and Machine Learning, Springer (2006), - also, excerpts from the book - Richard O. Duda, Peter E. Hart, David G. Stork: Pattern Classification, Wiley & Sons; 2nd edition (2000), - further literature will be announced in the lecture.

Number/Code	<derzeit nicht verfügbar/verpflichtend>
Module name	**FUNCTIONAL SAFETY IN BIOMEDICAL ENGINEERING**
Type of module	Selectable mandatory module
Learning results, competencies, qualification goals	The student will able to: - Know and understand Characteristics, basic concepts, and relevant safety standards of the Functional safety and reliability of computer systems. - Derive and apply methods to increase the reliability of computer systems - Select a suitable hardware safety architecture and Derive an appropriate security concept from it. - Know qualitative and quantitative methods for analyzing computer systems' functional safety and reliability, and derive and apply them. Learning outcomes related to program objectives: - Acquire and apply in-depth knowledge of concrete safety concepts for biomedical engineering systems according to applied functional safety standards. - Acquire and apply in-depth knowledge of models, methods, and structures to realize safety-oriented systems in the field of biomedical engineering. - Acquire and apply in-depth knowledge of calculation models, methods, and structures for evaluating and analyzing safety-related systems in the field of biomedical engineering. - Acquire and apply the verification possibilities concerning the certification of safety-related systems in the field of biomedical engineering.
Types of courses	4 SWS (semester periods per week): 2 SWS lecture 2 SWS exercise
Course contents	Characteristics, concepts of functional safety and reliability of computer systems, redundancy concepts, systematic and random errors, error handling in design and during operation, fault tolerance, of reliability, safety concepts, qualitative and quantitative methods for the consideration of functional safety, reliability calculation, calculation of safety parameters
Title of the course	**FUNCTIONAL SAFETY IN BIOMEDICAL ENGINEERING**
Teaching and learning methods (forms of teaching and learning)	Lecture, presentation, learning by teaching, self-regulated learning, problem-based learning
Applicability of the module	Study programs: Functional Safety Engineering
Duration of the offer of the module	one Semester

Frequency of the module offering	Summer semester
Langugage	English
Recommended (content-related) prerequisites for participation in the module	none
Prerequisites for participation in the module	Requirements according to the examination regulations
Student workload	180 h: 60 h attendance studies 120 h personal studies
Academic performances	None
Precondition for the admission to the examination performance	None
Examination performance	Written exam 60 - 180 min., or oral 20 - 40 min. depending on the number of participants will be announced in the first lecture.
Number of credits of the module	6 credits, including 1 credit integrated key competence - Media and analysis competence: Students learn to conduct and analyze independent research of subject-specific safety standards. They acquire the ability to deal purposefully and independently with standardized safety engineering procedures.
In charge of the module	Prof. Dr. Josef Börcsök
Teacher of the module	Prof. Dr. Josef Börcsök and co-workers, Dr. Ali Hayek, Prof. Dr. Roy Joseph ABI ZEID DAOU (Université La Sagesse)
Forms of media	Blackboard, slides, exercises
Literature references	- Script/slides will be handed out at the beginning of the event. - Börcsök J., Electronic Safety Systems, Hüthig 2004 - Börcsök J., Functional Safety, Hüthig, 2006 - Leitch, R. D., Reliability Analysis for Engineers, Oxford Science Publication 1995, - Goble, W., Evaluation Control Systems Reliability, ISA 1992, - further literature will be announced in the lecture.

VERIFICATION OF EMBEDDED SYSTEMS

Number/Code	<derzeit nicht verfügbar/verpflichtend>

Module name	Verification of embedded systems
Type of module	Selectable mandatory module
Learning results, competencies, qualification goals	The student masters basic techniques and formalisms used in the modeling and verification of embedded systems in safety-critical applications. They will be able to evaluate and apply them. Learning outcomes related to program objectives: - Acquire in-depth knowledge of fundamentals specific to electrical engineering. - Acquire advanced and applied fundamentals specific to the discipline - Recognition and classification of complex electrical engineering and interdisciplinary tasks - Confident application and evaluation of analytical methods - Independent development and evaluation of solution methods - An in-depth and essential experience in practical technical and engineering activities - Working and researching in national and international contexts
Types of courses	4 SWS
Course contents	- Real-time systems: Timed Automata, Region Graph, Zone Graph, Timed CTL, Timed Bisimulation, Uppaal - Probabilistic systems: Markov chains, Markov decision processes, Probabilistic CTL, Probabilistic bisimulation, Prism - Hybrid Systems: Differential Equations, Hybrid Automata, Linear Hybrid Automata, Selected Model Checking Tools
Title of the course	Verification of embedded systems
Teaching and learning methods (forms of teaching and learning)	Lecture, presentation, learning by teaching, self-regulated learning, problem-based learning
Applicability of the module	Study programs: Functional Safety Engineering, information technology
Duration of the offer of the module	one Semester
Frequency of the module offering	Summer semester
Langugage	After arrangement
Recommended (content-related) prerequisites for participation in the module	Theoretical computer science I + II, introduction to formal verification; basic knowledge of stochastics.
Prerequisites for participation in the module	none
Student workload	180 h: 60 h attendance studies

	120 h personal studies
Academic performances	Working on the weekly exercises and active participation in the exercises
Precondition for the admission to the examination performance	None
Examination performance	oral exam (30 min.) / written exam (90 min.) / term paper, depending on the number of participants
Number of credits of the module	6 credits
In charge of the module	Prof. Dr. Martin Lange
Teacher of the module	Prof. Dr. Martin Lange and co-workers
Forms of media	Projector, blackboard, piece of paper
Literature references	- Slides of this lecture - C. Baier, J.-P. Katoen. Principles of Model Checking, MIT Press, 2008 - Additional current research articles will be announced in the lecture.

SENSOR AND COMMUNICATION

SEMICONDUCTOR LASERS

Number/Code	<derzeit nicht verfügbar/verpflichtend>

Module name	Semiconductor Lasers
Type of module	Selectable mandatory module
Learning results, competencies, qualification goals	The student will be able to: - Understand the design and operation of semiconductor lasers and significant optoelectronic components and systems. - Overview of the enormous application potential of semiconductor lasers and optoelectronic components. - Understands the potential of optical information transmission for current and future safety issues. - Can design laser components to meet the highest safety levels SIL 4. - measure the complex interaction of electronic, thermal, and optical phenomena in laser diodes and evaluate which safety risks can arise from which phenomena. - Understand and design galvanic isolations to increase safety. - Recognize the relationships between optical, quantum mechanical, and acoustic resonators. - Solve previously unsolved problems through transfer and interdisciplinary analogies. - Can transfer nature's recipes for success concerning safety to engineering problems and thus exploit valuable synergies. Learning results concerning the objectives of the course of study: - Acquire in-depth knowledge of electrical engineering-specific fundamentals. - Acquisition of extended and applied subject-specific fundamentals. - Recognition and classification of complex electrotechnical and interdisciplinary tasks. - Confident application and evaluation of analytical methods. - Independent development and evaluation of solution methods. - An in-depth and essential experience in practical technical and engineering activities.
Types of courses	3 SWS: 2 SWS lecture 1 SWS exercise
Course contents	- One-, two- and three-dimensional optical gratings and photonic crystals. - Lasers: optical amplification, rate equations, DFB gratings, emission spectra, ultrafast lasers, tunable lasers, "chirped gratings," micro-disk lasers, quantum cascade lasers, DBR mirrors for vertical cavity lasers, VCSELs, blue semiconductor lasers - "Light processing": switches, splitters, amplifiers, multiplexers, demultiplexers, beam converters, switches - Optical communication systems: WDM, TDM - Showing analogies between optical, quantum mechanical and

	acoustic resonators, eigenvalues and eigenfunctions in Helmholtz, Schödinger and wave equations
Title of the course	**Semiconductor Lasers**
Teaching and learning methods (forms of teaching and learning)	Presentation, script, blackboard, exercise sheets, lab set-up, lab protocol.
Applicability of the module	Study program Functional Safety Engineering, Mechatronics, Nanostructure Science, Electrical Engineering, Electrical Communication Engineering, Sustainable Business, Industrial Engineering.
Duration of the offer of the module	one Semester
Frequency of the module offering	Winter semester
Langugage	English
Recommended (content-related) prerequisites for participation in the module	VL Materials of Electrical Engineering, VL Electronic Components, Optoelectronics I
Prerequisites for participation in the module	Optoelectronic devices (wave optics, waveguide, glass fibre)
Student workload	180h: 45 h attendance studies 135 h personal studies
Academic performances	None
Precondition for the admission to the examination performance	None
Examination performance	oral examination (30 min.)
Number of credits of the module	6 credits, of which 2 CP as integrated key competencies - Methodological competence, students have learned to work independently. They have the ability to apply abstract basic principles to concrete case studies from the everyday environment.
In charge of the module	Prof. Dr. Hillmer
Teacher of the module	Prof. Dr. Hillmer and co-workers
Forms of media	Presentation, script, blackboard, laboratory experiments
Literature references	- S. O. Kasap: Optoelectronics and photonics, Prentice Hall, 2001 - J. Singh: Semiconductor Devices – an Introduction, McGraw-Hill - J. Singh: Semiconductor Devices – Basic Principles, John Wiley & Sons, New York 2001 - K. J. Ebeling: Integrierte Optoelektronik, 2. Aufl., Springer Verlag, 1992 - H. Fouckhardt: Photonik, Teubner Verlag, Stuttgart 1994 - T.E. Sale: Vertical Cavity Surface Emitting Lasers, RSP, John Wiley & Sons, Chichester, UK, 1995 - C. Breck Hitz: Understanding Laser Technology, PennWell

	Books, Tulsa, Oklahoma, 1985 - L. A. Coldren and S. W. Corzine: Diode Lasers and Photonic Integrated Circuits, John Wiley & Sons, New York 1995 - S. L. Chuang: Physics of Optoelectronic Devices, John Wiley & Sons, New York 1995 - M. Young: Optics and lasers, Springer-Verlag, Heidelberg, 1993 - P. Bhattacharya: Semiconductor Optoelectronic Devices, 2nd edition, Prentice Hall, London 1997 - F. K. Kneubühl und M. W. Sigrist: Laser, Teubner Verlag, 1995 - O. Svelto and D. C. Hanna: Principles of Lasers, 4th edition, Plenum Press, New York 1998 - G.P. Agrawal and N.K. Dutta: Long-Wavelength Semiconductor Lasers, Van Nostrand Reinhold, New York, 1986 - H. Ghafouri-Shiraz und B.S.K. Lo: Distributed Feedback Laser Diodes: Principles and Physical Modelling, John Wiley & Sons, Chichester, UK, 1996 - S. M. Sze: Physics of semiconductor devices , John Wiley & Sons, New York - V. Brückner: Optische Nachrichtentechnik: Grundlagen und Anwendungen, Teubner Verlag, Stuttgart, 2003 - H. Hillmer und J. Salbeck: Kap. 8, "Materialien der Optoelektronik – Grundlagen und Anwendungen", in Bergmann Schäfer, Band 6, Festkörper, Auflage 2004, Walter de Gruyter Verlag, Berlin, New York. - K.Iga, S.Kinoshita: Process technology for semiconductor lasers, Springer, Series in Material Science 30, 1996. - Springer Handbook of Lasers and Optics, F. Träger (Editor), Springer, 2007 - further literature will be announced in the course.

OPTICAL COMMUNICATION SYSTEMS

Number/Code	OCS
Module name	**Optical Communication Systems**
Type of module	Selectable mandatory module

Learning results, competencies, qualification goals	The student will be able to: - analyze different system arrangements - name the standardization regulations - test whether the various components are suitable - plan optical transmission paths - establish electro-optical stages for high transmission rates - compare and evaluate optical communication systems - compare and classify literature sources Learning results concerning the objectives of the course of study: - Gaining more profound insight into the mathematical and natural science areas - Gaining a more profound knowledge of the specific electrical fundamentals - Acquiring enhanced and applied subject-specific basics - Identifying and classifying complex electro-technical and interdisciplinary tasks - Being confident in the ability to apply and evaluate analytical methods - Being able to create and evaluate solving methods independently - Familiarising oneself with new areas of knowledge, running searches, and assessing the results - Gaining important and profound experience in the area of practical technical skills and engineering activities - Working and researching in national and international contexts
Types of courses	5 SWS (semester periods per week): 2 SWS lecture 2 SWS seminar 1 SWS practical
Course contents	Principles of the fiber optic transmission, Fibre-to-the-X-technologies, WDM, photonic networks, SONET standard, system aspects, application of nano-photonic components in optical communication systems, electronic high-speed system components in optical communication systems
Title of the course	**Optical Communication Systems**
Teaching and learning methods (forms of teaching and learning)	Lectures, practical examples, student presentations, scientific discussions, self-study, and practical analyses in a simulation environment.
Applicability of the module	Study programs: Electrical Engineering, Electrical Communication Engineering, Functional Safety Engineering
Duration of the offer of the module	one Semester, usually weekly
Frequency of the module offering	Summer semester

Language	English
Recommended (content-related) prerequisites for participation in the module	Basic knowledge in the areas of communication systems and optoelectronic devices
Prerequisites for participation in the module	none
Student workload	180 h: 75 h attendance studies 105 h personal studies
Academic performances	Upon prior notification by the instructor, attendance records may be kept at the practicum.
Precondition for the admission to the examination performance	None
Examination performance	Form: written/oral, seminar presentation Duration: written 120 min/ oral 20 min
Number of credits of the module	6 credits and 3 credits of them apply to the integrated key competencies. Lecture: 3 credits Seminar: 2 credits practical: 1 credit
In charge of the module	Prof. Dr. Bangert
Teacher of the module	Prof. Dr. Bangertand co-workers
Forms of media	Projector, blackboard, overhead projector, PC including a simulation environment
Literature references	- J.Gowar, Optical Communication Systems, 2nd Ed., Prentice Hall, 1993. - S.L.Chuang, Physics of Optoelectronic Devices, John Wiley & Sons, New York, 1995. - G.P. Agrawal, Fiber-Optic Communication Systems, John Wiley & Sons, New York, 1997. - J.P.Laude, DWDM: Fundamentals, Components and Applications, Artech House, 2002.

RF SENSOR SYSTEMS

Number/Code	RFSS
Module name	**RF Sensor Systems**
Type of module	Selectable mandatory module

Learning results, competencies, qualification goals	The student will be able to: - Explain different radar procedures - Name safety regulations - Develop radiometric systems - Classify different sensor systems with respect to their applications - Classify microwave sources - Evaluate optical sources with respect to their suitability in radar systems Learning outcomes related to the program objectives: - Acquire in-depth knowledge in mathematical and scientific areas. - Acquire in-depth knowledge of the fundamentals specific to electrical engineering - Acquisition of advanced and applied fundamentals specific to the field of study - Recognition and classification of complex electrotechnical and interdisciplinary tasks - Confident application and evaluation of analytical methods - Independent development and evaluation of solution methods - Familiarization with new areas of knowledge, conducting research, and evaluating results - A deep and important experience in practical technical and engineering activities - Working and researching in national and international contexts
Types of courses	4 SWS (semester periods per week): 2 SWS lecture 1 SWS exercise 1 SWS practical
Course contents	Motivation, definitions of terms, basics of sensor technology, radar methods, wave characteristics, scanning methods, ultrasonic radar sensors, microwave sources, microwave antennas, laser radar, protection, and safety regulations.
Title of the course	**RF Sensor Systems**
Teaching and learning methods (forms of teaching and learning)	Lecture, self-study, exercises, practical investigations on radar systems and components.
Applicability of the module	Study programs: Functional Safety Engineering, Electrical Engineering, ECE, Mechatronics
Duration of the offer of the module	every Semester
Frequency of the module offering	Winter semester / Summer semester
Language	Bilingual

Recommended (content-related) prerequisites for participation in the module	Basic knowledge in the fields of high-frequency technology and measurement technology
Prerequisites for participation in the module	None
Student workload	180 h: 60 h attendance studies 120 h personal studies
Academic performances	None
Precondition for the admission to the examination performance	None
Examination performance	Form: written/oral, practical test Duration: written 120 min / oral 20 min After a prior announcement by the lecturer, attendance lists may be kept during the internship.
Number of credits of the module	6 credit Lecture/ exercise: 4 credits Practical: 2 credits
In charge of the module	Prof. Dr. Bangert
Teacher of the module	Prof. Dr. Bangertand co-workers
Forms of media	Projector, blackboard, overhead projector, lab.
Literature references	- H. Woodhouse, Introduction to Microwave Remote Sensing, Taylor&Francis, 2006. - E. Nyfors et al., Inductrial Microwave Sensors, Artech House, 1989. - J. Polivka, Overview of Microwave Sensor Technology, High Frequency Electronics, 2007.

FUNCTIONAL SAFETY IN BIOMEDICAL SENSOR SYSTEMS

Number/Code	<derzeit nicht verfügbar/verpflichtend>
Module name	**FUNCTIONAL SAFETY IN BIOMEDICAL SENSOR SYSTEMS**
Type of module	Selectable mandatory module

Learning results, competencies, qualification goals	The student will be able to: - Knowledge of biomedical sensors; - Recognize the function, advantages, and limitations of biosensors; - Choose the right sensors for medical applications; - Recognize the risks of biosensors on the human body; - The use of microsystems for health care; - Employ the safety measures that must be considered when designing and implementing microsystems. Learning outcomes related to program objectives: - Acquire and apply basic knowledge of sensors in biomedical engineering. - Recognize and classify complex engineering processes to understand biomedical engineering sensor systems. - Acquire in-depth knowledge to understand scientific relationships in biomedical systems. - Acquire in-depth and essential experience handling practical technical integrated systems in biomedical sensor technology. - Work and research in practical contexts.
Types of courses	4 SWS: 3 SWS lecture 1 SWS exercise
Course contents	This course is divided into three parts: - The first part introduces biomedical sensors. For this purpose, simple basics of different transducers (mechanical, thermal, magnetic, chemical, optical biosensors) are first introduced, and then microsensors for ions (ISFET), gas sensors (GASFET), and BioMEMS are presented; - The second part gives an overview of microsystems in biomedical engineering. A brief introduction to semiconductor technology is first given. The materials used in the process are presented. Some basic electronic circuits for sensors and microsystems (analog and digital) are then presented; - The third part deals with communication between sensors and microsystems in biomedical engineering.
Title of the course	**Functional Safety in Biomedical Engineering**
Teaching and learning methods (forms of teaching and learning)	Lecture, lecture, learning by teaching, self-directed learning, problem-based learning.
Applicability of the module	Study program: Functional Safety Engineering
Duration of the offer of the module	one Semester
Frequency of the module	Summer semester

offering	
Langugage	English
Recommended (content-related) prerequisites for participation in the module	None
Prerequisites for participation in the module	Requirements according to the examination regulations
Student workload	180 h: 60 h attendance studies 120 h personal studies
Academic performances	None
Precondition for the admission to the examination performance	None
Examination performance	Written exam 60 – 180 min., or oral 20 – 40 min. depending on the number of participants will be announced in the first lecture.
Number of credits of the module	6 credits, including 1 credit integrated key competence – communication and action competence: Students learn the ability to analyze and build complex systems of biomedical sensor technology. In doing so, they develop cooperation and teamwork skills.
In charge of the module	Prof. Dr. Josef Börcsök
Teacher of the module	Prof. Dr. Josef Börcsök and co-workers, Dr. Ali Hayek, Prof. Dr. Roy Joseph ABI ZEID DAOU (Université La Sagesse)
Forms of media	Blackboard, slides, exercises
Literature references	– Script/slides, will be handed out at the beginning of the event.

PATTERN RECOGNITION

Number/Code	<derzeit nicht verfügbar/verpflichtend>
Module name	**Pattern Recognition II**
Type of module	Selectable mandatory module
Learning results,	The student will able to:

competencies, qualification goals	- explain different tasks, models, and algorithms of pattern recognition, - develop new modeling approaches for classification and regression problems, - plan and implement new applications independently, - critically analyze, compare and evaluate existing methods and applications. Learning outcomes related to program objectives: - Acquire in-depth knowledge in the area of data-driven modeling of uncertainty and risk using probabilistic methods. - Acquire advanced and applied domain-specific fundamentals in classification and regression with functional safety and reliability applications. - Confidently apply and evaluate pattern recognition methods. - Independently develop and evaluate solutions, applications, and results based on pattern recognition methods in the area of functional safety and reliability. - Basic skills on scientific discussions in the field of pattern recognition.
Types of courses	4 SWS (semester periods per week): 3 SWS lecture 1 SWS exercise
Course contents	The lecture deals with the basics and methods of pattern recognition, especially from a probabilistic point of view. The following topics will be discussed: Fundamentals (including stochasticity, model selection, the curse of dimensionality, decision and information theory), distributions (including multinomial, Dirichlet, Gaussian and Student distributions, nonparametric estimation), linear models for regression, linear models for classification, mixed models and expectation maximization, statistical learning theory (support vector machines), example applications (online clustering, anomaly detection, etc.).
Title of the course	**Pattern Recognition II**
Teaching and learning methods (forms of teaching and learning)	Lecture, presentation, learning by teaching, self-regulated learning, problem-based learning
Applicability of the module	Study programs: Functional Safety Engineering, Electrical Engineering, Mechanical Engineering, Mechatronics, Computer Science, Mathematics
Duration of the offer of the module	one Semester
Frequency of the module offering	Winter semester
Langugage	Bilingual (English or German by arrangement)
Recommended (content-related) prerequisites for	Basic knowledge of stochastics, analysis, and linear algebra

participation in the module	
Prerequisites for participation in the module	none
Student workload	180 h: 60 h attendance studies 120 h personal studies
Academic performances	regular work on exercises
Precondition for the admission to the examination performance	None
Examination performance	mündliche Prüfung (20 Min.)
Number of credits of the module	6 credits
In charge of the module	Prof. Dr. Sick
Teacher of the module	Prof. Dr. Sick and co-workers
Forms of media	Presentation with beamer, computer exercises, paper exercises
Literature references	- Lecture slides, - various chapters of the book Christopher M. Bishop: Pattern Recognition and Machine Learning, Springer (2006), - also, excerpts from the book - Richard O. Duda, Peter E. Hart, David G. Stork: Pattern Classification, Wiley & Sons; 2nd edition (2000), - further literature will be announced in the lecture.

SAFETY STRUCTURES FOR VEHICLES

SAFETY ELECTRONICS SYSTEMS IN VEHICLES

Number/Code	<derzeit nicht verfügbar/verpflichtend>
Module name	**Safety Electronics Systems in Vehicles**

Type of module	Selectable mandatory module
Learning results, competencies, qualification goals	Students have learned the basic approach regarding the development of safety structures in the vehicle according to state of the art. Students are now able to understand the different safety architectures based on Functional Safety. Learning outcomes related to the elective module: - Acquire in-depth knowledge of ISO 26262 for automotive applications. - Acquire advanced and applied subject-specific fundamentals of safety engineering - Basic knowledge of complex electrotechnical safety architectures in automotive engineering - Confident evaluation of analytical safety architectures - Independent development and evaluation of solution methods Learning outcomes related to program objectives: - Acquire knowledge related to ISO standard 26262. - Safely apply and evaluate safety-related Concepts to determine ASIL ratings. - Acquire in-depth knowledge of safety-related electronic structures in motor vehicles. - Acquire in-depth knowledge of the determination of reliability parameters of different architectures in the environment of motor vehicles. - Acquisition of in-depth knowledge of special reliability models for hardware and software in vehicles. - Recognition and classification of complex electrotechnical and interdisciplinary - and interdisciplinary tasks in the context of Functional safety in the automotive environment. - Independently develop and evaluate solution methods in the in the automotive engineering environment. - In-depth and important experience in technical and engineering approaches of complex safety systems in safety systems in automotive engineering. - Acquisition of in-depth knowledge of diagnostic, test and - test structures for architectural models in safety engineering systems.
Types of courses	4 SWS (semester periods per week): 2 SWS lecture 2 SWS exercise
Course contents	Introduction to probability theory Reliability and reliability parameters System properties, system boundaries, system analysis Terminology of safety engineering Benefits of safety and reliability engineering

	Relationships between safety, quality and reliability Standardization, organizations, standardization procedures Ethics, roles and responsibilities Case studies Reliability and safety standards Concepts and parameters Requirements for fault detection Risk and hazard Risk and hazard analysis Example: EPS steering system in motor vehicles Reliability and safety engineering Fuse methods Calculation methods Simplifications Reliability of complex systems Calculation of safety parameters Reliability models for hardware and software in motor vehicles Provision of safety proofs Important estimation methods
Title of the course	**Safety Electronics in Vehicle Systems**
Teaching and learning methods (forms of teaching and learning)	Lecture, instructional discussion and group work.
Applicability of the module	Study program: Functional Safety Engineering
Duration of the offer of the module	one Semester
Frequency of the module offering	Summer semester
Langugage	English
Recommended (content-related) prerequisites for participation in the module	Basics mathematics
Prerequisites for participation in the module	Requirements according to the examination regulations
Student workload	180 h: 60 h attendance studies 120 h personal studies
Academic performances	None
Precondition for the admission to the examination performance	None
Examination performance	Written exam 60 – 180 min., or oral 20 – 40 min. depending on the

	number of participants, will be announced in the first lecture.
Number of credits of the module	6 credits, including 1 credit integrated key competence-. Interdisciplinary studies: training of logical thinking, methodological competence: students have learned to work independently with the structure of modern safety systems in motor vehicles. They have the ability to apply abstract basic principles to concrete case studies from everyday environments.
In charge of the module	Prof. Dr. Börcsök, Josef
Teacher of the module	Prof. Dr. Ossmane Krini
Forms of media	Projector, paper, blackboard, Demonstration and design work on the PC
Literature references	- Börcsök, Josef, Functional Safety - Basic Principles of Safety-related Systems Hüthig-Verlag Heidelberg, 2007 - Börcsök, Josef, Electronic Safety Systems - Hardware Concepts, Models and Calculations, Hüthig-Verlag Heidelberg, 2004 - IEC/EN 61508 (2010). International Standard: 61508 Functional safety of electrical, electronic programmable electronic safety-related systems Part1-Part7 - ISO 26262 Version 1 2012 - Martin Hillenbrand, Funktionale Sicherheit nach ISO 26262 in der Konzeptphase der Entwicklung von Elektrik / Elektronik Architekturen von Fahrzeugen, Karlsruher Institut für Technologie (KIT)

MODELING OF SAFETY STRUCTURE ACCORDING TO ISO 2626-2

Number/Code	<derzeit nicht verfügbar/verpflichtend>
Module name	**Modeling of safety structure according to ISO 2626-2**
Type of module	Selectable mandatory module

Learning results, competencies, qualification goals	Students will have the ability to theoretically model and design complex electronic systems for safety-critical applications in motor vehicles and to calculate them using standard mathematical methods. Furthermore, the course provides an understanding of the basic methods of statistics and their application. Students will learn the essential procedures for determining complex, mathematical and statistical problems. Learning outcomes related to the elective module: After completing the lecture, the students have knowledge of the mathematical considerations of complex electronic systems in motor vehicles. They will be able to solve basic problems in the field of statistics and safety engineering independently. Learning outcomes related to program objectives: - Understand how to apply mathematical procedure models to evaluate safety parameters for automotive engineering. - Independently develop and evaluate solution methods based on ISO 26262 - Acquire in-depth knowledge of the mathematical concepts for development methodology according to ISO 26262 - Acquire and apply in-depth knowledge of the Planning of the required verification and validation activities according to ISO 26262. - Acquire in-depth knowledge of special estimation methods their application in the field of functional safety and reliability in the automotive environment according to ISO 26262 - Acquire in-depth knowledge of the determination of safety integrity ASIL according to ISO 26262
Types of courses	4 SWS (semester periods per week): 2 SWS lecture 2 SWS exercise
Course contents	Introduction to safety engineering Introduction to electronics in the motor vehicle Safety-relevant electronic systems in the motor vehicle Mathematical development methods for safety-relevant systems Basics of safety, risk and hazard Reliability and availability Failure and fault tolerance Mathematical procedure models System development in different industrial areas System development in the automotive sector System development in the aviation sector System development in process automation Maturity models Mathematical concepts for development methodology

	Requirements for development methodology Safety integrity Automotive Safety Integrity Level (ASIL)
Title of the course	**Modeling of safety structure according to ISO standard 26262**
Teaching and learning methods (forms of teaching and learning)	Lecture, instructional discussion and group work.
Applicability of the module	Study program: Functional Safety Engineering
Duration of the offer of the module	one Semester
Frequency of the module offering	Summer semester
Langugage	English
Recommended (content-related) prerequisites for participation in the module	Basics mathematics
Prerequisites for participation in the module	Requirements according to the examination regulations
Student workload	180 h: 60 h attendance studies 120 h personal studies
Academic performances	None
Precondition for the admission to the examination performance	None
Examination performance	Written exam 60 - 180 min., or oral 20 - 40 min. depending on the number of participants, will be announced in the first lecture.
Number of credits of the module	6 credits, of which 1 credit integrated key competence Methodological competence, students have learned to work independently with the safety standard ISO 26262. They have the ability to apply abstract basic principles and procedural methods to concrete case studies from the everyday motor vehicle environment.
In charge of the module	Prof. Dr. Börcsök, Josef
Teacher of the module	Prof. Dr. Börcsök, Josef and co-workers, Prof. Dr. Ossmane Krini
Forms of media	Projector, paper, blackboard, Demonstration and design work on the PC
Literature references	- Papoulis: Probability, random variables, and stochastic processes, McGraw Hill, 1984 - S. Lipschutz: Wahrscheinlichkeitsrechnung - Theorie und Anwendung, McGraw Hill, 1976 - M. Fisz: Wahrscheinlichkeitsrechnung und mathematische Statistik, VEB Deutscher Verlag der Wissenschaften, 1989

	- F. Jondral, A. Wiesler, Wahrscheinlichkeitsrechnung und stochastische Prozesse, Teubner 2002 - Börcsök, Josef, Functional Safety - Basic Principles of Safety-related Systems Hüthig-Verlag Heidelberg, 2007 - Börcsök, Josef, Electronic Safety Systems - Hardware Concepts, Models and Calculations, Hüthig-Verlag Heidelberg, 2004 - Martin Hillenbrand, Funktionale Sicherheit nach ISO 26262 in der Konzeptphase der Entwicklung von Elektrik / Elektronik Architekturen von Fahrzeugen, Karlsruher Institut für Technologie (KIT)

COMPUTER BASED DESIGN OF MICROELECTRONIC CIRCUITS

Number/Code	<derzeit nicht verfügbar/verpflichtend>
Module name	**Computer based Design of microelectronic Circuits**

Type of module	Selectable mandatory module
Learning results, competencies, qualification goals	The student will be able to - Outline the process and goals of physical design, - explain given or known algorithms, - combine partial algorithms to an overall process - Compare implementations of given algorithms, - Develop implementations of algorithms, - Qualitatively evaluate placement and wiring results. - Explain and classify simulation methods Learning outcomes related to program objectives: - Acquire in-depth knowledge in mathematical and scientific areas. - Acquire in-depth knowledge in the fundamentals specific to electrical engineering - Acquisition of advanced and applied fundamentals specific to the field of study - Recognition and classification of complex electrotechnical and interdisciplinary tasks - Confident application and evaluation of analytical methods - Independent development and evaluation of solution methods - Familiarization with new areas of knowledge, conducting research and evaluating results - In-depth and important experience in practical technical and engineering activities - Working and researching in national and international contexts
Types of courses	3 SWS (semester periods per week): 2 SWS lecture 1 SWS exercise
Course contents	Building on the theoretical foundations, the methods and algorithms that form the basis for current industrial CAD systems for chip design are discussed, in each case following the design flow. This promotes a deeper understanding of how they work and enables the targeted use of these tools. Among other things, optimization methods, algorithms in physical design (partitioning, placement, wiring) as well as simulation algorithms will be covered.
Title of the course	**Computer based Design of microelectronic Circuits**
Teaching and learning methods (forms of teaching and learning)	Lecture, instructional discussion and group work.
Applicability of the module	Study programs: Electrical engineering, mechatronics, computer science, functional safety engineering
Duration of the offer of the module	one Semester
Frequency of the module	Summer semester

offering	
Langugage	German, English possible by arrangement
Recommended (content-related) prerequisites for participation in the module	Knowledge of discrete mathematics
Prerequisites for participation in the module	Requirements according to the examination regulations
Student workload	180 h: 45 h attendance studies 135 h personal studies
Academic performances	None
Precondition for the admission to the examination performance	None
Examination performance	Written exam (90 min.) or oral exam (approx. 40 min.)
Number of credits of the module	6 credits
In charge of the module	Prof. Dr. Peter Zipf
Teacher of the module	Prof. Dr. Peter Zipf and co-workers
Forms of media	Slides, projector, blackboard
Literature references	- Sabih H. Gerez: Algorithms for VLSI Design Automation, John Wiley & Sons, 1. Auflage, 1998 - Naveed A. Sherwani: Algorithms for VLSI Physical Design Automation, Springer Verlag; 3. Auflage. 1999 - Michael J. S. Smith: Application-Specific Integrated Circuits, Addison-Wesley Longman, 1997 - Jens Lienig: Layoutsynthese elektronischer Schaltungen, Springer Verlag, 1. Auflage, 2006 - Reinhard Diestel: Graphentheorie, Springer, Berlin; 3. Auflage, 2006 - Further literature will be announced in the lecture or on the homepage of the department.

VERIFICATION OF EMBEDDED SYSTEMS

Number/Code	<derzeit nicht verfügbar/verpflichtend>
Module name	**Verification of embedded systems**

Type of module	Selectable mandatory module
Learning results, competencies, qualification goals	The student will master basic techniques and formalisms used in the modeling and verification of embedded systems in safety-critical applications. He/she will be able to evaluate and apply these. Learning outcomes related to program objectives: - Acquire in-depth knowledge of electrical engineering specific fundamentals. - Acquisition of extended and applied subject-specific fundamentals - Recognition and classification of complex electrical engineering and interdisciplinary tasks - Confident application and evaluation of analytical methods - Independent development and evaluation of solution methods - In-depth and important experience in practical technical and engineering activities - Working and researching in national and international contexts
Types of courses	4 SWS (semester periods per week)
Course contents	- Real-time systems: Timed Automata, Region Graph, Zone Graph, Timed CTL, Timed Bisimulation, Uppaal - Probabilistic Systems: Markov Chains, Markov Decision Processes, Probabilistic CTL, Probabilistic Bisimulation, Prism - Hybrid Systems: Differential Equations, Hybrid Automata, Linear Hybrid Automata, Selected Model Checking Tools
Title of the course	**Verification of embedded systems**
Teaching and learning methods (forms of teaching and learning)	Lecture, instructional discussion and group work.
Applicability of the module	Study program: Functional Safety Engineering, Information Technology
Duration of the offer of the module	one Semester
Frequency of the module offering	Summer semester
Langugage	After arrangement
Recommended (content-related) prerequisites for participation in the module	Theoretical computer science I + II, introduction to formal verification; basic knowledge of stochastics.
Prerequisites for participation in the module	None
Student workload	180 h: 60 h attendance studies

	120 h personal studies
Academic performances	Working on the weekly exercises and active participation in the exercises
Precondition for the admission to the examination performance	None
Examination performance	oral exam (30 min.) / written exam / term paper, depending on number of participants
Number of credits of the module	6 credits
In charge of the module	Prof. Dr. Martin Lange
Teacher of the module	Prof. Dr. Martin Lange and co-workers
Forms of media	Presentation with beamer, blackboard, paper exercises
Literature references	- Lecture slides - C. Baier, J.-P. Katoen. Principles of Model Checking, MIT Press, 2008 - Other recent research articles will be announced in the lecture.

PATTERN RECOGNITION

Number/Code	<derzeit nicht verfügbar/verpflichtend>
Module name	**Pattern Recognition II**
Type of module	Selectable mandatory module
Learning results, competencies, qualification goals	The student will able to: - explain different tasks, models, and algorithms of pattern recognition, - develop new modeling approaches for classification and regression problems, - plan and implement new applications independently,

	- critically analyze, compare and evaluate existing methods and applications. Learning outcomes related to program objectives: - Acquire in-depth knowledge in the area of data-driven modeling of uncertainty and risk using probabilistic methods. - Acquire advanced and applied domain-specific fundamentals in classification and regression with functional safety and reliability applications. - Confidently apply and evaluate pattern recognition methods. - Independently develop and evaluate solutions, applications, and results based on pattern recognition methods in the area of functional safety and reliability. - Basic skills on scientific discussions in the field of pattern recognition.
Types of courses	4 SWS (semester periods per week): 3 SWS lecture 1 SWS exercise
Course contents	The lecture deals with the basics and methods of pattern recognition, especially from a probabilistic point of view. The following topics will be discussed: Fundamentals (including stochasticity, model selection, the curse of dimensionality, decision and information theory), distributions (including multinomial, Dirichlet, Gaussian and Student distributions, nonparametric estimation), linear models for regression, linear models for classification, mixed models and expectation maximization, statistical learning theory (support vector machines), example applications (online clustering, anomaly detection, etc.).
Title of the course	**Pattern Recognition II**
Teaching and learning methods (forms of teaching and learning)	Lecture, presentation, learning by teaching, self-regulated learning, problem-based learning
Applicability of the module	Study programs: Functional Safety Engineering, Electrical Engineering, Mechanical Engineering, Mechatronics, Computer Science, Mathematics
Duration of the offer of the module	one Semester
Frequency of the module offering	Winter semester
Langugage	Bilingual (English or German by arrangement)
Recommended (content-related) prerequisites for participation in the module	Basic knowledge of stochastics, analysis, and linear algebra
Prerequisites for participation in the module	none

Student workload	180 h: 60 h attendance studies 120 h personal studies
Academic performances	regular work on exercises
Precondition for the admission to the examination performance	None
Examination performance	mündliche Prüfung (20 Min.)
Number of credits of the module	6 credits
In charge of the module	Prof. Dr. Sick
Teacher of the module	Prof. Dr. Sick and co-workers
Forms of media	Presentation with beamer, computer exercises, paper exercises
Literature references	- Lecture slides, - various chapters of the book Christopher M. Bishop: Pattern Recognition and Machine Learning, Springer (2006), - also, excerpts from the book - Richard O. Duda, Peter E. Hart, David G. Stork: Pattern Classification, Wiley & Sons; 2nd edition (2000), - further literature will be announced in the lecture.