Fakultät für
Ingenieurwissenschaften und
Informatik

Modulhandbuch

Masterstudiengang Sensorsystemtechnik

Wintersemester 2022/2023

Basierend auf Rev. **269**. Letzte Änderung am **16.02.2022** um **09:17** durch **smoser**. Generiert am **25.10.2022** um **09:00** Uhr.

Inhaltsverzeichnis

1 Biochemical Sensors

Token / Number:	BCS
English title:	Biochemical Sensors
Credits:	6 ECTS
Language:	English or German
Turn / Duration:	every Winter Term / 1 Semester
Module authority:	Dott. Alberto Pasquarelli
Training staff:	Dott. Alberto Pasquarelli
Integration of module into courses of studies:	Sensor Systems Engineering, M.Sc., Elective Module, Sensor Technology Biopharmaceutical and Medical Engineering Sciences, M.Sc., Elective Module, Medical and Biomedical Technological Competencies
Requirements (contentual):	Basic knowledge of chemistry and biochemistry help in understanding the biological part of biosensors.
Learning objectives:	The world-wide needs for chemical detection and analysis rise steadily. Several reasons lead to this trend, for instance the rapid increase in the prevalence of diabetes, the increasing need for environmental and health monitoring, new legislative standards for food and drugs quality control or even the early detection of biological and chemical terror attacks. Thanks to higher sensitivity and specificity, short response times and reduction of overall costs, biosensors can be very competitive in addressing these needs when compared to traditional methods. Students can describe basic principles, mechanisms of action and applications of biosensors in different scenarios. After taking this module, participants are able to explain the chemical and physical fundamentals of biosensing. They are further able to analyze biosensors, break-down complex sensors in their elementary components and identify and evaluate every individual function in the information flow, from recognition to transduction and transmission. Students are capable of predicting the effects of elementary components in an integrated biosensor application. Students asses the clinical and industrial applications, differentiate biosensor market sectors regarding technical and economical properties, e.g. commodities for everyday consumer needs or professional equipment for research. Furthermore, they are able to reflect and critically analyze research in the field of biosensors. Finally students are capable of developing appropriate concepts and designs for given biosensing problems in industry and academia. They are further able to independently derive original solutions for new problems.
Content:	- Introduction to biosensors - Review of the basics of chemistry and molecular biology - Biological detection methods: catalytic, immunologic, etc. - Physical transduction methods: electrochemical, optical, gravimetric, etc. - Immobilization techniques: adsorption, entrapment, cross-linking, covalent bonds - Biochip technologies: DNA and protein chips, ion-channel devices, MEA and MTA, implants - Student seminars - Laboratory practice with experimental demonstrations and quantitative determinations of analytes

Literature:	- Handbook of Biosensors and Biochips, ISBN 9780470019054 - Alberts: Molecular biology of the cell 5th ed., ISBN 9780815341055 - Gizeli: Biomolecular sensors, ISBN 074840791X - Renneberg: Biosensing for the 21st Century, ISBN: 9783540752011 - Orellana: Frontiers in Chemical Sensors, ISBN: 9783540277576 - Homola: Surf. Plasmon Resonance Based Sensors, ISBN: 9783540339199 - Hierlemann: Int. Chem. Micr. Syst. in CMOS Techn., ISBN: 9783540273721 - Steinem: Piezoelectric Sensors, ISBN: 9783540365686 - Jay: Modern Food Microbiology, ISBN: 9780387234137 - Morrison: Defense against Bioterror, ISBN: 9781402033841 - Willner and Katz: Bioelectronics, ISBN: 3-527-30690-0 - Lecutre Notes
Basis for:	Master's thesis in the area of sensor technology
Modes of learning and effort estimation:	**On-campus meetings** (e.g. kick-off, laboratories, exercises, group work, presentations, and exam): 12 h, distributed over 3 days **Distance learning:** **Synchronous** (e.g. webinar, group work, presentation, chat): 12 h **Asynchronous** (e.g. self-study based on lecture notes, videos, literature, exercises, e-learning assignments): 156 h **Sum:** 180 h
Course assessment and exams:	Written exam: 2 h. For admission to the exam the following requirements have to be met: Successful completion of a seminar of 15 minutes and the evaluation of the data from the laboratory experiments. In case of hardship, the candidate can write an informal request to the coordinator in order to be given admission to the exam. In case of sickness a doctor's certicate has to be submitted to the coordinator.
Requirements (formal):	Requirement is a first academic degree.
Grading:	The grade of the module will be the grade of the exam.

2 Business Process Management

Kürzel / Nummer:	BPM
Englischer Titel:	Business Process Management
Leistungspunkte:	6 ECTS
Sprache:	Deutsch
Turnus / Dauer:	jedes Wintersemester / 1 Semester
Modulverantwortlicher:	Prof. Dr. Manfred Reichert
Dozenten:	Prof. Dr. Manfred Reichert
Einordnung des Moduls in Studiengänge:	Business Analytics, M.Sc., Pflichtmodul Sensorsystemtechnik, M.Sc., Wahlpflichtmodul, Management-Aspekte
Voraussetzungen (inhaltlich):	Grundlegende Kenntnisse zu Datenbanken, wie sie im Modul „Grundlagen von Datenbanksysteme“ vermittelt werden.
Lernziele:	Die Teilnehmer sind nach erfolgreicher Absolvierung des Moduls in der Lage, Geschäftsprozesse auf fachlicher Ebene zu analysieren, modellieren und optimieren. Sie können die dazu verfügbaren Methoden, Konzepte und Software-Werkzeuge anwenden. Des Weiteren können sie erklären, wie sich Geschäftsprozesse durch Informationssysteme unterstützen lassen und sind in der Lage, die für die Realisierung solcher prozessorientierten Informationssysteme bestehenden Anforderungen zu benennen. Die Teilnehmer können darüber hinaus die wesentlichen Charakteristika, Komponenten und Funktionen prozessorientierter Informationssysteme beschreiben und in einer Gesamtarchitektur einordnen. Weiter sind sie in der Lage, verschiedene Paradigmen zur Modellierung und Entwicklung prozessorientierter Informationssysteme zu beschreiben und anzuwenden sowie deren Vor- und Nachteile zu bewerten. Schließlich sind die Teilnehmer befähigt, ausgewählte Prozessszenarien mithilfe eines Prozess-Management-Systems zu implementieren.
Inhalt:	- Einführung in Business Process Management und Fallbeispiele - Charakteristika prozessorientierter Informationssysteme - Analyse und Optimierung fachlicher Geschäftsprozesse - Werkzeuge, Sprachen und Richtlinien für die fachliche Modellierung von Prozessen (z.B. Business Process Modeling Notation 2.0) - Modellierung und Verifikation ausführbarer Prozesse (d.h. Workflows) - Implementierung und Ausführung von Prozessen mithilfe von Prozess-Management-Technologie - Ausgewählte Architektur- und Implementierungsaspekte von Prozess-Management-Systemen - Konzepte und Technologien zur Unterstützung flexibler Prozesse - Aktuelle Trend im Bereich Business Process Management
Literatur:	- Vorlesungsskript und Übungsmaterialien - Reichert, M., Weber, B. (2012), Enabling Flexibility in Process-Aware Information Systems – Challenges, Methods, Technologies: Springer. - Weske, M. (2012), Business Process Management: Concepts, Languages, Architectures, 2. Auflage: Springer. - Dumas, M., La Rosa, M., Mendling, J., Reijers, H. (2013), Fundamentals of Business Process Management: Springer.

Lehrformen und Aufwandsabschätzung:	**Präsenzveranstaltungen:** (z.B. Einführungsveranstaltungen, Laborübungen, Gruppenarbeit, Präsentationen und Prüfungen): 18 h, über 5 Tage verteilt **Fernstudium:** **Synchron** (z.B. Webinar, Gruppenarbeit, Präsentation, Chat): 6 h **Asynchron** (z.B. Selbststudium auf Basis des Skripts, der Videos, der empfohlenen Literature, der Übungen, der Online-Abgaben): 156 h **Summe:** 180 h
Leistungsnachweis und Prüfungen:	Für die Zulassung zur Modulprüfung (Klausur/mündl. Prüfung) sind folgende Voraussetzungen zu erfüllen: Teilnahme an mindestens 2 Präsenzterminen. Erreichen von mindestens 50 % der in den Online-Modellierungsaufgaben erzielbaren Punkte Art und Umfang der Prüfungsform und gegebenenfalls weitere erforderliche Leistungsnachweise werden zu Beginn der Lehrveranstaltung bekannt gegeben. In Härtefällen kann ein formloser Antrag auf Zulassung zur Prüfung bei den Modulverantwortlichen gestellt werden. Bei Krankheit ist den Modulverantwortlichen ein ärztliches Attest vorzulegen.
Voraussetzungen (formal):	keine
Notenbildung:	Die Modulnote ergibt sich aus dem Ergebnis der Modulprüfung

3 Design Methodology of Embedded Systems

Token / Number:	EES
English title:	Design Methodology of Embedded Systems
Credits:	6 ECTS
Language:	English or German
Turn / Duration:	every Winter Term / 1 Semester
Module authority:	Prof. Dr.-Ing. Frank Slomka
Training staff:	Prof. Dr.-Ing. Frank Slomka
Integration of module into courses of studies:	Sensor Systems Engineering, M.Sc., Elective Module, System Design
Requirements (contentual):	Fundamentals of computer architecture or embedded systems architecture
Learning objectives:	In taking part in the module "Design Methodology of Embedded Systems" the students learn how to describe and sketch the model-based design of embedded systems. They will be able to name and distinguish different analytic processes for the assessment of embedded systems. From a set of different methods and algorithms for the analysis of real-time operation, they will learn how to pick a suitable method in order to solve a given problem. The participants will be enabled to build new methods and algorithms and to prove their correctness. The students will be able to identify the complexity of algorithms and to develop approximations. Moreover, they will be able to assess various designs of embedded systems and to compare them.
Content:	Even if you cannot see them – embedded systems are everywhere. Very often, the only time that we take notice of them is when they no longer function properly: All of a sudden, the expensive new car refuses to go any further. Doors in the shopping mall do not open or close anymore at closing time. The barrier in the parking garage remains closed. The smart phone cannot login at the network. Not only can certain bugs take away comfortable functions, incorrectly designed systems can be extremely dangerous and become very expensive. For example, there were certain incidents when rockets that had expensive satellites on board had to be blown up because they lost their intended trajectories and became a threat. One of the most cost-intensive mistakes throughout the history of embedded systems was the explosion of an "Ariane" rocket in 1996. The damage reached 370 Million US$ and was caused by an overflow of a register which on the other hand was the outcome of the fact that Ariane 5 accelerated quicker than the predecessor Ariane 4. Embedded Systems became so complex during the course of the last decades that methods of computer-assisted design have to be applied. This module deals with the building of models and the analysis of embedded systems, focusing on the design of a uniform model for event-driven real-time systems. The course focuses mainly on: - Model-based design of embedded systems - Time and real-time systems - Modelling of embedded systems: event models and graphs - Intrinsic analysis of real-time systems - Extrinsic analysis of real-time systems - Complexity and approximation of the extrinsic analysis - Optimization and Design Space Exploration

Literature:	- Jürgen Teich: Digitale Hardware-/Software Systeme, Springer 1996 - Peter Liggesmeyer und Dieter Rombach: Software Engineering eingebetteter Systeme, Spektrum Akademischer Verlag 2005 - Jean J. Labrosse: Embedded Systems Building Blocks, CMP 2000 - Peter Marwedel: Eingebette Systeme, Springer 2007 - Zbigniew Michalewicz und David B. Fogel: Modern Heuristics, Springer, 2000
Modes of learning and effort estimation:	**On-campus meetings** (e.g. kick-off, laboratories, exercises, group work, presentations, and exam): 13 h, distributed over 3 days **Distance learning:** **Synchronous** (e.g. webinar, group work, presentation, chat): 28 h **Asynchronous** (e.g. self-study based on lecture notes, videos, literature, exercises, e-learning assignments): 139 h **Sum:** 180 h
Course assessment and exams:	Oral exam: 0.5 h - 1 h For admission to the exam the following requirements have to be met: Successful completion of the exercise assignments. Attending the on-campus days is mandatory.
Requirements (formal):	Requirement is a first academic degree.
Grading:	The grade of the module will be the grade of the exam.

4 High-Frequency Microsystems

Token / Number:	HFM
English title:	High-Frequency Microsystems
Credits:	6 ECTS
Language:	English or German
Turn / Duration:	every Winter Term / 1 Semester
Module authority:	Prof. Dr.-Ing. Hermann Schumacher
Training staff:	Prof. Dr.-Ing. Hermann Schumacher
Integration of module into courses of studies:	Sensor Systems Engineering, M.Sc., Elective Module, System Design
Requirements (contentual):	In order to successfully participate in this module, you will need foundations in electrical engineering, calculations of complex alternating currents, and fundamentals in analog electronics.
Learning objectives:	Students identify various areas of application for compact high-frequency and microwave systems in telecommunication and sensors. They will analyse the application and determine requirements to the housing technology and connective technology under special requirements of high operating frequencies. Based on simple case studies, students will identify advantages and disadvantages of "System-On-Chip", as well as a "System-In-Package" approach and identify possible uses for micro-electro-mechanical components in high-frequency microsystems. Finally, students will evaluate a complex case study that looks at circuit technology, assembly technology, and micromechanical components in their interaction within microsystems.
Content:	- High-frequency microsystems: Overview - Ambient intelligence as a high-frequency microsystem use scenario - Wireless sensor networks scenario - Trends in the semiconductor industry - Semiconductor technologies for micro- and millimeter-wave ICs (MMICs) - MMIC design methodologies - Packaging technologies for high-frequency microsystems - Packaging and interconnect parasitics - Technology of micro-electro-mechanical structures for radio frequency applications (RFMEMS) - RFMEMS components - RFMEMS/BiCMOS integration - Final case study: 30 GHz active antenna system - Virtual design lab
Literature:	- S. Prasad, H. Schumacher, A. Gopinath: High Speed Electronics and Optoelectronics - G. Rebeiz: RFMEMS: Theory, Design, and Technology

Modes of learning and effort estimation:	**On-campus meetings** (e.g. kick-off, laboratories, exercises, group work, presentations, and exam): 11 h, distributed over 3 days **Distance learning:** **Synchronous** (e.g. webinar, group work, presentation, chat): 52 h **Asynchronous** (e.g. self-study based on lecture notes, videos, literature, exercises, e-learning assignments): 117 h **Sum:** 180 h
Course assessment and exams:	Oral exam consisting of preparing a concept paper, presentation and discussion: 0.5 h - 1 h. For admission to the exam the following requirements have to be met: Successful completion of the design exercises.
Requirements (formal):	Requirement is a first academic degree.
Grading:	The grade of the module will be the grade of the exam.

5 Management-Aspects of Systems Engineering I

Token / Number:	SyE-I
English title:	Management-Aspects of Systems Engineering I
Credits:	6 ECTS
Language:	English or German
Turn / Duration:	every Summer Term / 1 Semester
Module authority:	Michael Leute (Fa. Airbus Defence and Space)
Training staff:	Michael Leute Sascha Ackva
Integration of module into courses of studies:	Sensor Systems Engineering, M.Sc., Elective Module, Management Aspects
Requirements (contentual):	None
Learning objectives:	Today, starting at household applications providing automation services up-to highly complex systems as the International Space Station a lot of functionality is integrated and thus systems get more and more complex. In addition, the environment a system is installed imposes constraints increasing the complexity. Those constraints could be raised by a competitive market, by already installed systems or are given by laws and regulation. Systems Engineering has developed over the decades from a capability of a few experienced senior engineers to an acknowledged profession. Systems Engineering has proven to be a key enabling factor for companies to handle and manage complexity and to ensure effective communication among all stakeholders allowing developing successful systems. The course provides the rationale and foundation for applying Systems Engineering and an introduction into the thinking of Systems Engineering. The students explain the difference of a system in comparison to its system elements. They describe the role of a systems engineer within a project organisation and his or her work areas. The students understand the importance of upfront analysis in order to avoid unplanned costs in later life cycle stages. They recognize that communication, e.g. with specialist disciplines, is a fundamental element of the SE tasks. They further analyse a system completely on a specific abstraction level considering the complete life cycle before advancing into deeper details towards implementation. The students work with a wide scope overlooking all technical aspects of the whole system instead of focusing solely on a single detail. The students elicit requirements starting from the stakeholder needs, identify possible solution architectures, perform trade studies and decompose and allocate the requirements down the system hierarchy. They apply different techniques to validate architecture, design and requirements. The students manage the technical aspects of a system and coordinates with the specialist engineering disciplines as well as project management.

Content:	- Definition of a system and systems engineering, system hierarchy and development lifecycle - Justification and rationale for the systems engineering discipline i.e. managing complexity, effective communication and common understanding - The role of the systems engineer - Systems engineering processes - Typical reviews (quality gates) in the development life cycle, and their objectives - Requirements engineering - System architecture - Integration and testing - Project life cycle and development models
Literature:	- INCOSE Systems Engineering Handbook (ISBN 978-1-937076-02-3) - Systems Engineering, Principles and Practice, Kossiakoff et.al.
Modes of learning and effort estimation:	**On-campus meetings** (e.g. kick-off, laboratories, exercises, group work, presentations, and exam): 16 h, distributed over 4 days **Distance learning:** **Synchronous** (e.g. webinar, group work, presentation, chat): 24 h **Asynchronous** (e.g. self-study based on lecture notes, videos, literature, exercises, e-learning assignments): 140 h **Sum:** 180 h
Course assessment and exams:	Written exam, multiple choice: 2 h. For admission to the exam the following requirements have to be met: Successful completion of the exercise assignments. Attending the on-campus days is mandatory.
Requirements (formal):	Requirement is a first academic degree.
Grading:	The grade of the module will be the grade of the exam.

6 Management-Aspects of Systems Engineering II

Token / Number:	SyE-II
English title:	Management-Aspects of Systems Engineering II
Credits:	6 ECTS
Language:	English or German
Turn / Duration:	every Winter Term / 1 Semester
Module authority:	Michael Leute (Fa. Airbus Defence and Space)
Training staff:	Michael Leute Sascha Ackva
Integration of module into courses of studies:	Sensor Systems Engineering, M.Sc., Elective Module, Management Aspects
Requirements (contentual):	Management-Aspects of Systems Engineering I
Learning objectives:	After working through this course, the students will be able to explain risk and opportunity management and the reasons for its application. They describe the differences between safety and security and they will be aware of some major standards in this area and their application domain. Based on a product breakdown structure (PBS) of the system, they will identify the related work for each item. Based on the work break down structure (WBS) they generate the inputs for project planning. Reuse within product families is a major precondition to be competitive with one's products in a demanding market. After working through this course the students will know the basics and the methods for product family engineering, which is a beneficial approach to foster planned reuse in development projects. They will use feature models to manage system element variations and associated feature constraints. A second focus of the course is model-based systems engineering (MBSE) enabling a more efficient and structured way to manage and design complex systems. After working through this course they will apply modelling technics and methods for analysing the problem space and for structuring the system. The participants will be able to explain the differences between UML and SysML and they will know the basic modelling elements of SysML. They will recognize and explain the advantages of a model based tooling compared to a simple graphical drawing tool and they will understand the SysML diagrams as a view on the model elements and their associations and relations. At the end of the module, the students will be able to use use-cases to identify major operational scenarios with the stakeholders with its required high level functions and collaboration aspects, thus allowing eliciting a concise set to stakeholder requirements. The participants will use SysML to structure the system and to show hierarchical relations. Furthermore, they will use SysML activity charts and state charts to model the behaviour of a system, as well as its operational modes and states.

Content:	- MBSE: 1. Modelling with SysML, basics and terms 2. Use-case analysis 3. Structure diagrams 4. Behaviour diagrams - Introduction to risk and opportunity management - Difference between product safety, functional safety, and security. Introduction to major standards in this area. - Planning using PBS and WBS - Introduction to product family engineering and feature models
Literature:	- INCOSE Systems Engineering Handbook, English (ISBN: 978-1-937076-02-3) - INCOSE Systems Engineering Handbuch, German (http://www.gfse.org) - Systems Engineering, Principles and Practice, Kossiakoff et.al. - Practical Guide to SysML (ISBN: 978-0-128002-02-5) - Systems Engineering mit SysML/UML (ISBN: 978-3-864900-91-4)
Modes of learning and effort estimation:	**On-campus meetings** (e.g. kick-off, laboratories, exercises, group work, presentations, and exam): 16 h, distributed over 4 days **Distance learning:** **Synchronous** (e.g. webinar, group work, presentation, chat): 12 h **Asynchronous** (e.g. self-study based on lecture notes, videos, literature, exercises, e-learning assignments): 152 h **Sum:** 180 h
Course assessment and exams:	Written exam, multiple choice: 2 h. For admission to the exam the following requirements have to be met: Successful completion of the exercise assignments. Attending the on-campus days is mandatory.
Requirements (formal):	Requirement is a first academic degree.
Grading:	The grade of the module consists of: Written exam: 60 % Project paper: 40 %

7 Mixed-Signal CMOS Chip Design

Token / Number:	CCD
English title:	Mixed-Signal CMOS Chip Design
Credits:	4 ECTS
Language:	English or German
Turn / Duration:	every Summer Term / 1 Semester
Module authority:	Prof. Dr.-Ing. Maurits Ortmanns
Training staff:	Dr.-Ing. Joachim Becker
Integration of module into courses of studies:	Sensor Systems Engineering, M.Sc., Elective Module, System Design
Requirements (contentual):	Basics of CMOS technology, analog circuit design, digital circuit design
Learning objectives:	After successful completion of this course, students understand the working principles of analog and digital circuit simulation techniques. They are able to set up a node admittance matrix from a given circuit and know the working principles and applications of the three main analog simulation types: DC, AC, and transient. They understand linearization of device models and Newton-Raphson integration for solution of differential equations, update and residue criteria, and equilibrium points. Furthermore, they understand process variation and device mismatch and their influence on CMOS circuits and are able to use worst case corner modeling and statistical evaluation methods like Monte Carlo analysis for yield optimization and design centering. They can elaborate the difference between cycle-based and event-driven digital simulation techniques, including half-step simulation and time-wheel scheduling. They are able to use setup- and hold-time constraints as well as contamination- and propagation-delays for calculation of slack times in a static timing analysis and can explain the effect of clock skew and jitter on synchronous circuits. They can elaborate how table-based models and circuit-partitioning is able to significantly speed up simulations and enables mixed-signal verification. They can estimate the tradeoff between manual modeling, compiled-model interface, and coupled co-simulation for mixed-mode analyses. They understand synthesis of combinational and synchronous behavioral hardware description into generic gates. Furthermore, they are able to use the stuck-at fault-model and the D-algorithm in order to analyze testability and include boundary-scan Flip-Flops for improved testability. They know principles of placement and routing of standard-cells including mincut algorithm, maze- and channel-routing, and layout compaction, as well as design-rule-check and layout-versus-schematic-check. They are able to build a clock-distribution network and make use of timing aware placement, as well as build a power-grid and apply I/O-cells in order to improve the reliability of digital circuits. Finally, they know various bonding-techniques and printed-circuit-board design practices in order to connect the final ASIC to other chips and measurement equipment.

Content:	- Analog simulation - Digital simulation - Mixed-signal and co-simulation - Design for reliability - Design for testability - CMOS layout, floorplanning, standard-cells - Layout parasitic extraction and verification - Packaging and board design
Literature:	- Baker - CMOS : Circuit design, layout, and simulation. - Razavi - Design of Analog CMOS Integrated Circuits. - Allen, Holberg - CMOS Analog Circuit Design. - Sedra, Smith - Microelectronic Circuits.
Modes of learning and effort estimation:	**On-campus meetings** (e.g. kick-off, laboratories, exercises, group work, presentations, and exam): 1 h **Distance learning:** **Synchronous** (e.g. webinar, group work, presentation, chat): 24 h **Asynchronous** (e.g. self-study based on lecture notes, videos, literature, exercises, e-learning assignments): 95 h **Sum:** 120 h
Course assessment and exams:	Oral exam: 0.5 h - 1 h
Requirements (formal):	Requirement is a first academic degree.
Grading:	The grade of the module will be the grade of the exam.

8 Modellbildung und Identifikation

Kürzel / Nummer:	MuI
Englischer Titel:	Modeling and identification
Leistungspunkte:	6 ECTS
Sprache:	Deutsch
Turnus / Dauer:	jedes Sommersemester / 1 Semester
Modulverantwortlicher:	Dr. Soehnke Rhein
Dozenten:	Dr. Soehnke Rhein
Einordnung des Moduls in Studiengänge:	Sensorsystemtechnik, M.Sc., Wahlpflichtmodul, Grundlagen der Systemtechnik
Voraussetzungen (inhaltlich):	- Grundlagenkenntnisse der höheren Mathematik (insbesondere lineare Algebra) - Grundlagen der Regelungstechnik im Frequenz- und Zeitbereich
Lernziele:	Im Modul werden Methoden der mathematischen Modellierung technischer Prozesse basierend auf physikalischen Prinzipien vermittelt. Ziel ist insbesondere die Fähigkeit, für den Regler- und Beobachterentwurf geeignete Modelle herzuleiten und mit Hilfe von Identifikationsverfahren zu parametrieren. Geeignete Beschreibungen von Systemen bilden die Grundlage vieler regelungstechnischer Methoden und werden bei der Systemanalyse über die Regelung bis hin zur modellbasierten Überwachung benötigt. Modellbasierte Verfahren eröffnen insbesondere umfassende Verbesserungsmöglichkeiten vieler bestehender industrieller Regelungen. Unabdingbare Voraussetzung dafür sind geeignete mathematische Modelle, die auf der einen Seite die wichtigsten dynamischen Effekte hinreichend genau abbilden und auf der anderen Seite eine beherrschbare Komplexität aufweisen. Ebenso wichtig ist die Bestimmung nicht für direkte Messungen zugänglicher Parameter dieser Modelle. Die für diese Aufgaben notwendigen mathematischen und systemtheoretischen Grundlagen werden im Modul vermittelt. Nach Abschluss des Moduls sind die Studierenden in der Lage, technische Systeme aus unterschiedlichen physikalischen Domänen mathematisch in ihrem dynamischen Verhalten zu beschreiben. Sie beherrschen die wichtigsten analytischen Methoden, diese Systeme geeignet zu parametrieren beziehungsweise mit Hilfe von sogenannten Blackbox-Modellen zu identifizieren. Die Studierenden können die Zusammenhänge, die zur Entwicklung optimaler Zustandsschätzer und -regler führen, erklären und die entsprechenden Methoden in der Identifikation, Schätzung und Regelung anwenden.
Inhalt:	- Modellierung mechanischer, elektrischer und hydraulischer Systeme - Parametrische und nichtparametrische Identifikationsverfahren - Optimale Schätzverfahren und Filter (Kalman Filter)
Literatur:	- P.E. Wellstead: Physical Systems Modelling, Academic Press, 1979 - R. Isermann: Mechatronische Syteme: Grundlagen, Springer, 2002 - R. Isermann: Identifikation dynamischer Systeme 1 und 2, Springer, 1992 - D.G. Luenberger: Optimization by Vector Space Methods, John Wiley & Sons, 1969 - A. Gelb: Applied Optimal Estimation, M.I.T. Press, 1974 - A.E. Bryson, Y.-C. Ho: Applied Optimal Control, Hemisphere Publishing Corporation, 1975
Grundlage für:	

Lehrformen und Aufwandsabschätzung:	**Präsenzveranstaltungen:** (z.B. Einführungsveranstaltungen, Laborübungen, Gruppenarbeit, Präsentationen und Prüfungen): 3 h, über 2 Tage verteilt **Fernstudium:** **Synchron** (z.B. Webinar, Gruppenarbeit, Präsentation, Chat): 12 h **Asynchron** (z.B. Selbststudium auf Basis des Skripts, der Videos, der empfohlenen Literature, der Übungen, der Online-Abgaben): 165 h **Summe:** 180 h
Leistungsnachweis und Prüfungen:	Zur Modulprüfung wird zugelassen, wer die Übungen erfolgreich absolviert hat. Die Modulprüfung erfolgt mündlich.
Voraussetzungen (formal):	Modul Systemtheorie und Regelungstechnik
Notenbildung:	Die Modulnote ergibt sich aus der Modulprüfung.

9 Monolithic Microwave IC Design

Token / Number:	MMIC
English title:	Monolithic Microwave IC Design
Credits:	6 ECTS
Language:	English or German
Turn / Duration:	every Summer Term / 1 Semester
Module authority:	Prof. Dr.-Ing. Hermann Schumacher
Training staff:	Prof. Dr.-Ing. Hermann Schumacher
Integration of module into courses of studies:	Sensor Systems Engineering, M.Sc., Elective Module, System Design
Requirements (contentual):	- Principles of analog circuit design - Principles of radio-frequency engineering - Fundamental knowledge of transistor function (pHEMT, MOSFET, BJT)
Learning objectives:	Students recognize fundamental requirements of microwave/millimeter-wave communication systems. They review and analyze common circuit concepts and topologies, and identify those which meet the requirements. They then synthesize circuits to meet a set of requirements, and assess their functional performance using computer aided design tools, compare their results with the requirements, leading to circuit optimization.
Content:	1. General overview of monolithic microwave IC (MMIC) design techniques 2. MMIC design tools and models 3. Substrate properties, packaging parasitics, and their impact on MMIC design 4. Fundamental building blocks: a) Amplifiers (low-noise, wideband, power) b) Artificial transmission lines and distributed circuit topologies c) Mixers d) Oscillators e) Frequency multipliers and dividers f) Phase shifters and vector modulators The subject matter is presentend in a series of video lectures, as well as a script. It is then used in circuit design case studies, presented online in textual form and during webinars. Fundamental circuit blocks are also treated in practical design exercises, which will be done by course participants using Keysight ADS on the school's remote tool server.
Literature:	
Basis for:	Master thesis with MMIC design emphasis
Modes of learning and effort estimation:	**On-campus meetings** (e.g. kick-off, laboratories, exercises, group work, presentations, and exam): 12 h, distributed over 3 days **Distance learning:** **Synchronous** (e.g. webinar, group work, presentation, chat): 28 h **Asynchronous** (e.g. self-study based on lecture notes, videos, literature, exercises, e-learning assignments): 140 h **Sum:** 180 h

Course assessment and exams:	Oral exam in the form of a design review, where the student presents a design based on a paper provided 6 weeks before the exam. For admission to the oral exam the following requirements have to be met: Participation in the practical design exercises is required for registration to the exam. In case of hardship the candidate can write an informal request to the coordinator in order to be given admission to the exam. In case of sickness a doctor's certicate has to be submitted to the coordinator.
Requirements (formal):	Requirement is a first academic degree.
Grading:	The exam consists of an oral presentation (weight: 0.4) and a following discussion (weight: 0.6). The grade of the module will be the grade of the exam. Credit points will be awarded after successful completion of the exam.

10 Pattern Recognition and Deep Learning

Token / Number:	PRDL
German title:	Mustererkennung und mehrschichtiges Lernen
Credits:	6 ECTS
Language:	English
Turn / Duration:	every Winter Term / 1 Semester
Module authority:	apl. Prof. Dr. Friedhelm Schwenker
Training staff:	apl. Prof. Dr. Friedhelm Schwenker
Integration of module into courses of studies:	Sensor Systems Engineering, M.Sc., Elective Module, Fundamentals of Systems Engineering
Requirements (contentual):	Basic knowledge in programming and basic concepts of analysis, linear algebra, and probability.
Learning objectives:	Students acquire knowledge about different methods and algorithms of pattern recognition and deep artificial neural networks. In exercises, students are able to implement the basic algorithms, will apply pattern recognition principles to technical applications, and learn how to evaluate the performance of classifiers.
Content:	In this course the basic topics on statistical pattern recognition and deep neural networks are introduced: - Introduction to statistical and neural pattern recognition - Linear and nonlinear classifiers - Kernel methods and learning deep neural network - Feature extraction, selection and reduction - Applications and system performance evaluation
Literature:	- Bishop, Chris: Pattern Recognition and Machine Learning, Springer, 2007 - Theodoridis, Sergios & Koutroubas, Konstantionos, Pattern Recognition, Academic Press, 2010 - Charu Aggarwal: Neural Networks and Deep Learning, Springer, 2018
Modes of learning and effort estimation:	**On-campus meetings** (e.g. kick-off, laboratories, exercises, group work, presentations, and exam): 8 h **Distance learning:** **Synchronous** (e.g. webinar, group work, presentation, chat): 28 h **Asynchronous** (e.g. self-study based on lecture notes, videos, literature, exercises, e-learning assignments): 144 h **Sum:** 180 h
Course assessment and exams:	Oral exam
Requirements (formal):	Requirement is a first academic degree.
Grading:	Grade of the module will be the grade of the exam.

Basierend auf Rev. **233**. Letzte Änderung am **01.02.2021** um **14:53** durch **smoser**.

11 Project Management - Processes, Activities and Practices

Token / Number:	PMP
German title:	Project Management - Processes, Activities and Practices
Credits:	6 ECTS
Language:	English or German
Turn / Duration:	every Summer Term / 1 Semester
Module authority:	Dr. Volker Kraus
Training staff:	Dr. Volker Kraus
Integration of module into courses of studies:	Sensor Systems Engineering, M.Sc., Elective Module, Project Management - Processes, Activities and Practices
Requirements (contentual):	
Learning objectives:	Students who have successfully completed this module - are familiar with the basics of operational project management. - can independently plan, realize, monitor and control complex interdisciplinary-tasks. - are familiar with the various organizational forms of project management, the-coordination of work in project teams, and the requirements and tasks of apro-ject manager. - are proficient in the basic planning techniques of project management - are able to use different methods for planning, controlling and monitoringpro-cesses based on network planning technology. - know the challenges of project management by means of practical examples.
Content:	- Ethics and Compliance. - Motivation, concept formation and basic elements of project management. - Business case and project selection criteria. - Project environment within an organization. - The role of the project manager in the company. - Project phases: initiate, plan, execute, monitor and close. - Scenarios and exercises to enhance knowledge transfer for selected topics. - Knowledge Areas: ○ Stakeholder Management ○ Integration Management ○ Scope management ○ Scheduling Management ○ Cost Management ○ Quality Management ○ Resource management ○ Communication Management ○ Risk Management ○ Procurement Management
Literature:	- A guide to the project management body of knowledge (PMBOK guide) / Project Management Institute. Sixth edition. Newtown Square, PA; Project Management Institute, 2017. ISBN: 978-1-62825-184-5 - Project Management Institute: Code of Ethics and Professional Conduct. - PMI Practice guides and selected additional literature for the relevant knowledge areas (will be cited during lectures).

Modes of learning and effort estimation:	**On-campus meetings** (e.g. kick-off, laboratories, exercises, group work, presentations, and exam): 0 h **Distance learning:** **Synchronous** (e.g. webinar, group work, presentation, chat): 24 h **Asynchronous** (e.g. self-study based on lecture notes, videos, literature, exercises, e-learning assignments): 156 h **Sum:** 180 h
Course assessment and exams:	Written test or presentation (depending on number of students).
Requirements (formal):	Requirement is a first academic degree
Grading:	The grade of the module will be the grade of the exam.

12 Radarsensoren

Kürzel / Nummer:	RS
Englischer Titel:	Radar sensors
Leistungspunkte:	4 ECTS
Sprache:	Deutsch
Turnus / Dauer:	jedes Sommersemester / 1 Semester
Modulverantwortlicher:	Prof. Dr.-Ing. Wolfgang Menzel
Dozenten:	Prof. Dr.-Ing. Wolfgang Menzel
Einordnung des Moduls in Studiengänge:	Sensorsystemtechnik, M.Sc., Wahlpflichtmodul, Sensorik
Voraussetzungen (inhaltlich):	Signale und Systeme, Felder und Wellen, Einführung in die HF-Technik
Lernziele:	Radarsensoren werden seit vielen Jahrzehnten zur Überwachung von Flug und Schiffsverkehr sowie in diversen militärischen Systemen eingesetzt. In den letzten Jahren ist eine ganze Reihe von neuartigen Anwendungen im kommerziellen Bereich dazu gekommen, erwähnt werden sollen hier nur Radarsensoren in der Automobiltechnik oder der industriellen Messtechnik. Weitere Entwicklungen gehen in Richtung kompakt integrierter, abbildender Systeme mit immer größerem Anteil der Signalverarbeitung. Dieses Modul führt die Lernenden in die Thematik ein und lenkt den Blickpunkt auch auf neuere Entwicklungen. Nach der Belegung des Moduls sind die Studierenden in der Lage, die Prinzipien der Hochfrequenztechnik und der Mikrowellentechnik zum Entwurf und der messtechnischen Überprüfung von Systemen der Funkmesstechnik (Radartechnik) anzuwenden. Sie können die Vor- und Nachteile unterschiedlicher Radarsensorsysteme und deren Subsysteme sowie unterschiedliche Radiometer- und Radaranwendungen bewerten.
Inhalt:	- Ausbreitungseigenschaften von Mikrowellen in der Atmosphäre - Radiometrie - Radar mit den verschiedenen Radarverfahren, ihrer Realisierung, ihren Eigenschaften (CW-, FMCW-, Pulsradar, phasengesteuertes Radar, Beamforming, SAR) - Radarantennen
Literatur:	- Baur: Einführung in die Radartechnik, Teubner, 1985 - Collin: Antennas and Radiowave Propagation. McGraw-Hill, Singapore 1985 - Detlefsen: Radartechnik : Grundlagen, Bauelemente, Verfahren, Anwendungen, Springer Verlag - Huder: Einführung in die Radartechnik, Teubner, 1999 - Johnson: Antenna engineering handbook, McGraw-Hill, 1984 - Kark: Antennen und Strahlungsfelder, Viehweg, Wiesbaden, 2004 - Klausing, Holpp: Radar mit realer und synthetischer Apertur. Oldenbourg, München, Wien, 2000 - Ludloff: Handbuch Radar und Radarsignalverarbeitung, Vieweg, 1993 - Silver: Microwave antenna theory and design, Peregrinus, 1986 - Skolnik: Introduction to radar systems, McGraw-Hill , 1981 - Skolnik: Radar Handbook, McGraw-Hill, 1990 - Vohwinkel: Passive Mikrowellenradiometrie, Vieweg , 1988

Grundlage für:	Masterarbeiten im Bereich der Radarsensoren und -antennen
Lehrformen und Aufwandsabschätzung:	**Präsenzveranstaltungen:** (z.B. Einführungsveranstaltungen, Laborübungen, Gruppenarbeit, Präsentationen und Prüfungen): 11 h, verteilt über 3 Tage **Fernstudium:** **Synchron** (z.B. Webinar, Gruppenarbeit, Präsentation, Chat): 6 h **Asynchron** (z.B. Selbststudium auf Basis des Skripts, der Videos, der empfohlenen Literature, der Übungen, der Online-Abgaben): 103 h **Summe:** 120 h
Leistungsnachweis und Prüfungen:	Die Modulprüfung erfolgt mündlich.
Voraussetzungen (formal):	Keine
Notenbildung:	Die Modulnote ergibt sich aus der Modulprüfung.

Attendance at the webinar (online presentation with groups of about 4 to 5 students at a time). Successful participation (attendance time: 66 %) in the webinar (attendance certificate) is a requirement for admission to the exam.

13 Sensor Principles and Integrated Interface Circuits

Token / Number:	IIC
English title:	Sensor Principles and Integrated Interface Circuits
Credits:	6 ECTS
Language:	English or German
Turn / Duration:	every Summer Term / 1 Semester
Module authority:	Prof. Dr. Jens Anders (University of Stuutgart
Training staff:	Prof. Dr. Jens Anders
Integration of module into courses of studies:	Sensor Systems Engineering, M.Sc., Elective Module, Sensor Technology
Requirements (contentual):	Fundamentals in analog integrated circuits.
Learning objectives:	The students can identify the most relevant noise sources in sensors and sensor readout electronics and predict their effect on the achievable limit of detection. They can distinguish between self-generating and modulating sensors and classify different sensor types with respect to their electrical behavior. The students distinguish different readout concepts including amplitude, phase and frequency sensitive detection and apply these concepts to design example sensory systems. They can explain the advantages and disadvantages of continuous and discrete sensor readout circuits for a given application context. The students can differentiate open-loop and closed-loop readout concepts and identify the pros and cons of each approach for a given target application. The students evaluate the performance difference between absolute and difference measurement systems and their applicability for the formation of integrated circuit based sensors and sensor readouts. The students analyze and synthesize important readout circuit configurations including instrumentation amplifiers, transimpedance amplifiers and switched capacitor readout circuits. The students analyze and compare different A/D and D/A converter structures concerning their achievable performance and suitability for a given sensor application. The students can explain the concept of time-to-digital conversion and analyze common T/D converter architectures.
Content:	1. Motivation and example sensor applications - Chemical sensors (pH sensors, gas sensors, . . .) - Sensors for mechatronics (Hall sensors, gyroscopes, pressure sensors, . . .) - Medical imaging sensors (MRI detectors, X-Ray and CT detectors, ultrasound transducers, . . .) 2. Noise in sensors and integrated sensor readout circuits 3. Sensor types - Self-generating vs. modulating sensors - Electrical behavior (R, L, C, I-source, V-source, etc.)

Content (continued):	4. Readout concepts - Amplitude and frequency sensitive detection - Resonant readouts - Phase-sensitive detection (lock-in amplifiers) - Continuous-time vs. discrete-time readout - Open-loop vs. closed-loop readout - Absolute vs. difference measurements 5. Readout circuit implementations - Instrumentation amplifiers - Transimpedance amplifiers - Switched-capacitor readout circuits 6. Data converters for sensor readouts - A/D converters - D/A converters - T/D converters
Literature:	- P.P.L. Regtien: Measurement science for engineers. 358 p. Kogan Page Science: London ; Sterling, VA, 2004. - ISBN 1903996589 - P.P.L. Regtien: Sensors for mechatronics. Elsevier: Boston, MA, 2012. - ISBN 9780123914972 - B.R. Bannister: Instrumentation: Transducers and Interfacing. Springer, 2013. - ISBN 9780412342400
Modes of learning and effort estimation:	**On-campus meetings** (e.g. kick-off, laboratories, exercises, group work, presentations, and exam): 1 h **Distance learning:** **Synchronous** (e.g. webinar, group work, presentation, chat): 20 h **Asynchronous** (e.g. self-study based on lecture notes, videos, literature, exercises, e-learning assignments): 159 h **Sum:** 180 h
Course assessment and exams:	Oral exam: 0.5 h - 1 h
Requirements (formal):	Requirement is a first academnic degree.
Grading:	The grade of the module will be the grade of the exam.

14 Signals and Systems

Token / Number:	SaS
English title:	Signals and Systems
Credits:	6 ECTS
Language:	English or German
Turn / Duration:	every Winter Term / 1 Semester
Module authority:	Dr. Werner Teich
Training staff:	Dr. Werner Teich
Integration of module into courses of studies:	Sensor Systems Engineering, M.Sc., Elective Module, Fundamentals of Systems Engineering
Requirements (contentual):	Advanced Mathematics
Learning objectives:	The concepts of signals and systems are powerful tools for any engineer dealing with information bearing, measurable physical quantitites. Areas of applications include, among others, communications engineering, signal processing, control engineering, and systems engineering. The students will be able to classify, interpret, and compare signals and systems with respect to their characteristic properties. They can explain and apply analytical and numerical methods to analyze and synthesize signals and systems in time and frequency domain. Suitable signal transformations can be chosen and calculated with the help of transformation tables. The students are able to recognize stochastic signals and analyze them based on their characteristic properties. They can calculate and interpret the influence of linear time-invariant systems on stochastic signals.
Content:	- Basic properties of discrete-time and continuous-time systems - Z-transform - Basic properties of discrete-time and continuous-time systems - Linear time-invariant systems, convolution integral - Fourier transform, discrete Fourier transform, Fourier series - Sampling theorem - Probability theory, random variables and stochastic processes - Stochastic signals and linear time-invariant systems
Literature:	- Alan V. Oppenheim and Alan S. Willsky: Signals and Systems, Prentice Hall 1996 - Mrinal Mandal and Amir Asif: Continuous and Discrete Time Signals and Systems, Cambridge University Press, 2007 - Athanasios Papoulis and S. Unnikrishna Pillai: Probability, Random Variables, and Stochastic Processes, McGraw-Hill, 2002 - Thomas Frey und Martin Bossert: Signal- und Systemtheorie, B.G. Teubner Verlag, 2004 - Jens Ohm und Hans Dieter Lüke: Signalübertragung, Springer Verlag 2010

Modes of learning and effort estimation:	**On-campus meetings** (e.g. kick-off, laboratories, exercises, group work, presentations, and exam): 3 h, distributed over 2 days **Distance learning:** **Synchronous** (e.g. webinar, group work, presentation, chat): 28 h **Asynchronous** (e.g. self-study based on lecture notes, videos, literature, exercises, e-learning assignments): 149 h **Sum:** 180 h
Course assessment and exams:	Oral exam: 0.5 h - 1 h
Requirements (formal):	Requirement is a first academic degree.
Grading:	Grade of the module will be the grade of the exam.

15 Solid-State Sensors

Token / Number:	SStS
English title:	Solid-State Sensors
Credits:	6 ECTS
Language:	English or German
Turn / Duration:	every Summer Term / 1 Semester
Module authority:	Dott. Alberto Pasquarelli
Training staff:	Dott. Alberto Pasquarelli
Integration of module into courses of studies:	Sensor Systems Engineering, M.Sc., Elective Module, Sensor Technology
Requirements (contentual):	Basic knowledge of solid-state physics and electronics
Learning objectives:	The advances in microelectronics and micro electro-mechanical systems (MEMS) have revolutionized the scenario of sensor technology. Thanks to new materials and processes, traditional bulky, slow and expensive sensor systems could be replaced by miniaturized and integrated smart sensors based on semiconductors. With the help of solid-state sensors, various application areas have been developed. In everyday life, we encounter them, for example in the form of navigation and control systems in vehicles or as microphones, accelerometers, compass and cameras in mobile phones and tablets. In addition to the automotive industry and the mobile communications, solid-state sensors find applications in many other areas, for example in health care to record the blood pressure or body temperature in real time. Students can describe and explain principles of operation, technological implementations and application areas of different sensors. They are further able to classify given semiconductor sensors according to fundamental principles. They recognize and discuss the various physical phenomena in semiconductors, which are exploited for the detection of physical quantities and their conversion to electrical signals. They know various semiconductor materials suitable for the production of sensors, analyze the special properties of each one, explain and predict their response under different conditions and can calculate sensor examples for different measurement needs. The students can design a solid-state sensor choosing the right material among several semiconductors. They are able to analyze a measurement problem, compare appropriate sensing techniques and develop their own solution. Doing this they can properly dimension the sensor unit to meet the design specifications. Furthermore, the students are able to reflect and critically analyze research in the field of seminconductor sensors.
Content:	- **Review of the basics of:** - Sensor system design - Operational amplifiers - Solid-state physics - **Semiconductor-based detection methods for:** - Radiation (ionizing and non-ionizing) - Magnetic fields - Mechanical forces - Temperature - **Basics on MEMS (micro electro-mechanical systems)**

Literature:	- Rockett A., The Materials Science of Semiconductors, ISBN 978-0-387-68650-9 - Fraden J., Handbook of Modern Sensors, ISBN 978-3-319-19302-1 - McGrath M.J. et al, Sensor Technologies, ISBN 978-1-4302-6014-1 - Pierret R.F., Semiconductor fundamentals, ISBN 0-201-12295-2 - Pierret R.F., Field effect devices, ISBN 0-201-05323-3 - Middelhoek S., Audet S.A., Silicon Sensors, ISBN 0-12-495051-5 - Popovic R.S., Hall effect Devices, ISBN 0-7503-0096-5 - Michalski L. et al., Temperature measurements, ISBN 0-471-92229-3 - Selmic R.R. et al, Wireless Sensor Networks, ISBN 978-3-319-46769-6 - Lecutre Notes
Basis for:	Master's thesis in the area of sensor technology.
Modes of learning and effort estimation:	**On-campus meetings** (e.g. kick-off, laboratories, exercises, group work, presentations, and exam): 2 h **Distance learning:** **Synchronous** (e.g. webinar, group work, presentation, chat): 12 h **Asynchronous** (e.g. self-study based on lecture notes, videos, literature, exercises, e-learning assignments): 166 h **Sum:** 180 h
Course assessment and exams:	Written Exam: 2 h. For admission to the exam the following requirements have to be met: Successful completion of all exercises. In case of hardship, the candidate can write an informal request to the coordinator in order to be given admission to the exam. In case of sickness a doctor's certicate has to be submitted to the coordinator.
Requirements (formal):	Requirement is a first academic degree.
Grading:	The grade of the module will be the grade of the exam.

16 Systemtechnik

Kürzel / Nummer:	SyT
Leistungspunkte:	6 ECTS
Sprache:	Deutsch
Turnus / Dauer:	jedes Sommersemester / 1 Semester
Modulverantwortlicher:	Prof. Dr.-Ing. Jian Xie
Dozenten:	Prof. Dr.-Ing. Jian Xie
Einordnung des Moduls in Studiengänge:	Sensorsystemtechnik, M.Sc., Wahlpflichtmodul, Grundlagen der Systemtechnik
Voraussetzungen (inhaltlich):	- Berechnung von Gleichstrom- und Wechselstromkreisen - Grundkenntnisse über elektronische Bauelemente und Schaltungen
Lernziele:	Der Erfolg eines Unternehmens hängt immer mehr von der Fähigkeit ab, komplexe und interdisziplinäre Projekte erfolgreich zu gestalten. Die Systemtechnik beschreibt Methoden, Strategien und Vorgehensweisen zur Abwicklung von solchen komplexen Vorhaben. Durch die Belegung dieses Moduls werden die Studierenden dazu befähigt, Projekte effizient und zielgerichtet zu planen, zu steuern und abzuwickeln. Die Studierenden können Grundbegriffe der Systemtechnik beschreiben, Denksätze darstellen und anwenden sowie alternative Vorgehensmodelle skizzieren. Sie lernen Betrachtungsweisen, Techniken und Vorgehensschritte für die Situationsanalyse, Zielformulierung, Synthese-Analyse sowie Bewertung und Entscheidung kennen und anwenden. Sie können Aufgaben und Inhalte verschiedener Projektphasen benennen und beschreiben sowie Projektorganisationen klassifizieren, vergleichen, analysieren und einsetzen, die Einsatzgebiete verschiedener Projektorganisationen darstellen und Hilfsmittel wie Organigramme, Netzpläne, Ressourcenpläne oder Fortschrittspläne anwenden.
Inhalt:	- Kennenlernen von Denkweisen, Methoden und Hilfsmitteln der Systemtechnik - Philosophie der Systemtechnik mit Grundbegriffen und Anwendung - Vorgehensmodelle wie Top Down, Variantenbildung, Phasengliederung, Problemlösungszyklus - Systemgestaltung mit Verfahren wie Situationsanalyse, Zielformulierung, Synthese-Analyse, Bewertung und Entscheidung - Projektmanagement mit Schwerpunkten wie Projektphasen, Organisationen, Methoden und Hilfsmitteln - Gruppenübung zu einem Entwicklungsprojekt
Literatur:	- Haberfellner/Nagel: Systems Engineering, Verlag Industrielle Organisation Zürich
Lehrformen und Aufwandsabschätzung:	**Präsenzveranstaltungen:** (z.B. Einführungsveranstaltungen, Laborübungen, Gruppenarbeit, Präsentationen und Prüfungen): 11 h, verteilt über 4 Tage **Fernstudium:** **Synchron** (z.B. Webinar, Gruppenarbeit, Präsentation, Chat): 16 h **Asynchron** (z.B. Selbststudium auf Basis des Skripts, der Videos, der empfohlenen Literature, der Übungen, der Online-Abgaben): 153 h **Summe:** 180 h
Leistungsnachweis und Prüfungen:	Zur Modulprüfung wird zugelassen, wer die Aufgaben aus den Übungen erfolgreich bearbeitet hat. Die Modulprüfung erfolgt mündlich.

Voraussetzungen (formal):	Keine
Notenbildung:	Die Modulnote ergibt sich aus der Modulprüfung.

17 Systemtheorie und Regelungstechnik

Kürzel / Nummer:	SuR
Englischer Titel:	Systems theory and automatic control
Leistungspunkte:	6 ECTS
Sprache:	Deutsch
Turnus / Dauer:	jedes Wintersemester / 1 Semester
Modulverantwortlicher:	Dr. Soehnke Rhein
Dozenten:	Dr. Soehnke Rhein
Einordnung des Moduls in Studiengänge:	Sensorsystemtechnik, M.Sc., Wahlpflichtmodul, Grundlagen der Systemtechnik
Voraussetzungen (inhaltlich):	- Grundlagenkenntnisse der höheren Mathematik (insbesondere lineare Algebra) - Beschreibung linearer, zeitinvarianter Systeme (LTI) im Frequenzbereich, Laplace-Transformation, Analyse von LTI-Systemen (Bode-/Nyquist-Diagramm) - Grundlagen der Regelungstechnik im Frequenzbereich, Entwurfsverfahren für lineare zeitinvariante Systeme im Frequenzbereich
Lernziele:	Im Modul werden vertiefte Kenntnisse der Regelungstechnik im Zeitbereich vermittelt. Ziel ist insbesondere die Beherrschung von Methoden zur modellbasierten Regelung von linearen Systemen und in Grundzügen von nichtlinearen Systemen. In zunehmendem Maße verschärfte Anforderungen an Sicherheit, Nachhaltigkeit und Wirtschaftlichkeit technischer Produkte und Produktionsanlagen erfordern den Einsatz moderner automatisierungs- und regelungstechnischer Methoden. Insbesondere im Bereich der Regelungstechnik stoßen einfache und meist heuristisch entworfene Regelungen sehr schnell an ihre Grenzen. Der systematische Entwurf modellbasierter Regelungen im Zeitbereich erlaubt insbesondere auch die Berücksichtigung von Nichtlinearitäten und hat somit das Potential, signifikante Verbesserungen bestehender Regelungsergebnisse zu erzielen. Die dafür notwendigen mathematischen und systemtheoretischen Grundlagen sowie konkrete Entwurfsmethoden werden im Modul vermittelt. Nach Abschluss des Moduls sind die Studierenden in der Lage, lineare zeitkontinuierliche Systeme im Zeitbereich zu untersuchen und entsprechend ihrer systemtheoretischen Eigenschaften einzuordnen. Sie können die wichtigsten Methoden zum Entwurf von Regelungen im Zeitbereich anwenden. Nach Belegung des Moduls kennen die Studierende zudem einige für die Regelung nichtlinearer Systeme geeignete Methoden und beherrschen deren Einsatz.
Inhalt:	- Lineare und nichtlineare zeitkontinuierliche Systeme im Zustandsraum, Linearisierung und allgemeine Lösung linearer Zustandsdifferentialgleichungen - Strukturelle Eigenschaften linearer zeitkontinuierlicher Systeme im Zustandsraum (Stabilität, Steuerbarkeit, Beobachtbarkeit) - Entwurf von Zustandsreglern und Zustandsbeobachtern für lineare Systme - Analyse von nichtlinearen Systemen (Stabilität nach Lyapunov) - Steuerung und Regelung nichtlinearer Systeme

Literatur:	- J. Lunze: Regelungstechnik 1: Systemtheoretische Grundlagen, Analyse und Entwurf einschleifiger Regelungen. 4 Auflage Springer-Verlag, Berlin, 2006 - J. Lunze: Regelungstechnik 2: Mehrgrößensysteme, Digitale Regelung. Springer-Verlag, Berlin, 2004 - T. Kailath: Linear Systems. Prentice Hall, Upper Saddle River, 1980 - W.J. Rugh: Linear System Theory, Prentice Hall, 1996 - H.K. Khalil. Nonlinear Systems. Prentice Hall, Upper Saddle River, 2002 - S. Sastry. Nonlinear Systems. Springer, New York, 1999 - A. Isidori. Nonlinear Control Systems. Springer, Berlin, 3rd edition, 1995
Grundlage für:	
Lehrformen und Aufwandsabschätzung:	**Präsenzveranstaltungen:** (z.B. Einführungsveranstaltungen, Laborübungen, Gruppenarbeit, Präsentationen und Prüfungen): 13 h, verteilt über 2 Tage **Fernstudium:** **Synchron** (z.B. Webinar, Gruppenarbeit, Präsentation, Chat): 12 h **Asynchron** (z.B. Selbststudium auf Basis des Skripts, der Videos, der empfohlenen Literature, der Übungen, der Online-Abgaben): 155 h **Summe:** 180 h
Leistungsnachweis und Prüfungen:	Zur Modulprüfung wird zugelassen, wer die Übungen erfolgreich absolviert hat. Die Modulprüfung erfolgt mündlich.
Voraussetzungen (formal):	keine
Notenbildung:	Die Modulnote ergibt sich aus der Modulprüfung.

18 Using the Advanced Design System (ADS) in Electronic Design

Token / Number:	ADS
German title:	Einsatz von Advanced Design System (ADS) beim Entwurf elektronischer Systeme
Credits:	4 ECTS
Language:	English or German
Turn / Duration:	every Summer Term / 1 Semester
Module authority:	Dr.-Ing. Christoph Bromberger
Training staff:	Dr.-Ing. Christoph Bromberger
Integration of module into courses of studies:	Sensor Systems Engineering, M.Sc., Elective Module, System Design
Requirements (contentual):	- Bachelor-Level Analog Design Skills - Some understanding of S-parameters is helpful
Learning objectives:	The students gain an in-depth understanding of a significant analog simulation tool. They demonstrate their abilities to set up as well as to stream-line circuit simulations. Attendees employ ADS in high-frequency layout. They are used to ADS data structures and recognize ways to fully exploit their composition. Participants regularly scrutinize and critically judge their simulation results.
Content:	- The ADS project structure - Setting up, performing and simplifying schematics simulations - Using the data display - Understanding ADS data structures - Measurement Equations - Optimizing circuits with the help of ADS - (Semi-) automatic layout generation - 2d electromagnetic simulation - Exporting the layout
Literature:	- ADS handbooks and tutorials - http://edownload.soco.agilent.com/eedl/ads/2012_08/zip/ADS2012PDF.zip
Modes of learning and effort estimation:	**Distance learning:** **Synchronous** (e.g. webinar, group work, presentation, chat): 16 h **Asynchronous** (e.g. self-study based on lecture notes, videos, literature, exercises, e-learning assignments): 104 h **Sum:** 120 h
Course assessment and exams:	Written or oral exam
Requirements (formal):	Requirement is a first academic degree.
Grading:	The grade of the module will be the grade of the exam.

Basierend auf Rev. **269**. Letzte Änderung am **16.02.2022** um **09:17** durch **smoser**.

19 Wireless Sensor Networks

Token / Number:	WSN
English title:	Wireless Sensor Networks
Credits:	6 ECTS
Language:	English or German
Turn / Duration:	every Winter Term / 1 Semester
Module authority:	Prof. Dr. rer. nat. Frank Kargl
Training staff:	Prof. Dr. rer. nat. Frank Kargl
Integration of module into courses of studies:	Sensor Systems Engineering, M.Sc., Elective Module, Sensor Technology Sensor Systems Engineering, M.Sc., Elective Module, System Design
Requirements (contentual):	Fundamentals in computer networks, operating systems, and computer architectures. Programming skills in C or Python.
Learning objectives:	Students can explain the essential requirements and unique challenges of wireless ad-hoc networking; they can identify differences to classical wired networks and explain them. Given specific application requirements, students are able to design simple examples of wireless sensor network systems and construct and evaluate these systems. In particular, students are able to select existing routing and data dissemination strategies and adapt or extend them to suit specific scenarios. They can describe state of the art of wireless sensor network research and seminal research works. Using the acquired methods, students independently analyze new literature in sub-domains that were not covered in the lectures. They explain fundamental concepts of security and privacy protection in WSNs, select appropriate protection mechanisms, and integrate them in system architectures.
Content:	- Introduction to Wireless Sensor Networks (WSN): requirements, applications, and examples - Hardware and software platforms for WSNs - Link-layer technologies for WSN communication - Networking protocols and data dissemination strategies - WSN security and privacy - Simulative and experimental evaluation - Related domains (e.g., vehicular ad-hoc networks, delay-tolerant networks)
Literature:	
Modes of learning and effort estimation:	**On-campus meetings** (e.g. kick-off, laboratories, exercises, group work, presentations, and exam): 3 h, distributed over 2 days **Distance learning:** **Synchronous** (e.g. webinar, group work, presentation, chat): 82 h **Asynchronous** (e.g. self-study based on lecture notes, videos, literature, exercises, e-learning assignments): 95 h **Sum:** 180 h
Course assessment and exams:	Oral exam: 0.5 h - 1 h
Requirements (formal):	Requirement is a first academic degree.

Grading: The grade of the module will be the grade of the exam.

20 Masterarbeit

Kürzel / Nummer:	MA
Englischer Titel:	Master's Thesis
Leistungspunkte:	30 ECTS
Sprache:	Deutsch/Englisch
Turnus / Dauer:	jedes Semester / 1 Semester
Modulverantwortlicher:	Prof. Dr.-Ing. Hermann Schumacher
Dozenten:	Erstbetreuer der Masterarbeit
Einordnung des Moduls in Studiengänge:	Sensorsystemtechnik, M.Sc., Pflichtmodul, Masterarbeit
Voraussetzungen (inhaltlich):	Wünschenswert ist es, grundlegende Module aus dem Gebiet der Masterarbeit belegt zu haben.
Lernziele:	Selbstständiges Einarbeiten und wissenschaftlich methodische Bearbeitung eines für die Sensorsystemtechnik relevanten Themas. Erwerb der Fähigkeiten, komplexe Fragestellungen der Ingenieurwissenschaften unter Anwendung des erlernten Fachwissens sowie bekannter wissenschaftlicher Methoden und Erkenntnisse innerhalb eines vorgegebenen Zeitrahmens selbständig zu bearbeiten, in Form einer Ausarbeitung darzustellen und vor sachkundigem Publikum verständlich zu präsentieren. Erlernen von Schlüsselqualifikationen wie Management eines eigenen Projekts, Präsentationstechnik und Verfeierung der rhetorischen Fähigkeiten.
Inhalt:	Abhängig von der konkreten Themenstellung.
Literatur:	Abhängig von der konkreten Themenstellung.
Lehrformen und Aufwandsabschätzung:	Masterarbeit Wahl eines geeigneten Themas an einem der Institute der Ingenieurwisschaften (Dozenten der Ingenieurwissenschaften) Präsenzzeit: 10 h **Summe:** 900 h
Leistungsnachweis und Prüfungen:	Schriftliche Ausarbeitung und Abschlussvortrag.
Voraussetzungen (formal):	keine
Notenbildung:	Die Modulnote wird gemäß Prüfungsordnung gebildet.

Basierend auf Rev. **253**. Letzte Änderung am **01.06.2021** um **11:38** durch **kwunderlich**.