Electives
Artificial Intelligence and Data Science
Winter Semester

Faculty Computer Science
Date: 06.08.2025

TECHNISCHE HOCHSCHULE DEGGENDORF

Electives
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Generell Information

The module handbook applies to Electives 1–4. Electives from the bachelor's course Artificial Intelligence AIN-B can only be chosen for Electives 1 and 2 in the first semester.

In addition to the subject-specific compulsory elective modules, which are offered in English, students may choose individual an advanced language course A2 as elective 4, in the same language that you have your language course A1.

The list includes only electives offered at DIT. Students can also choose additional electives offered at USB.

Important: If German is specified as the language of instruction for an elective course, then the examination will also be conducted in German!

Table of Contents

AIX-B-4 Quantum Computing

Module code	AIX-B-4
Module coordination	Prof. Dr. Patrick Glauner
Course number and name	FWP-4 Quantum Computing
Original study program	X-Katalog FWP AI
Lecturers	Prof. Dr. Patrick Glauner Prof. Dr. Horst Kunhardt
Duration of the module	1 semester
Module frequency	annually, winter semester
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	Examination form of the chosen module (specialized exam for M-AID students)
Language of Instruction	English

Module Objective
This class provides students with an introduction to Quantum Computing (QC), which looks promising to solve certain computational problems substantially faster than classical computers. QC began in the early 1980s and in recent years, investment into QC research has increased in both the public and private sectors. Students will acquire knowledge in QC and its applications in various domains such as machine learning and cryptography. They will also be able to elaborate it further in the future, for example in projects or further studies. Overall, QC is a cutting-edge field, with many high-pay opportunities for graduates.

Applicability in this and other Programs
Miscellaneous

Entrance Requirements
- Programming
- Algorithms and data structures
- Mathematics, in particular linear algebra

Learning Content
- Introduction: history, comparison to traditional computing, applications, business potentials
- Foundations: complex numbers, complex vector spaces

- Systems: deterministic systems, probabilistic systems, quantum systems, assembling systems

- Quantum theory: states, superposition, observables, measuring, dynamics, assembling quantum systems, entanglement
- Architecture: bits and qubits, classical gates, reversible gates, quantum gates, no-cloning theorem
- Selected algorithms: Deutsch's, Deutsch-Jozsa, Simon's, Grover's, Shor?s
- Theoretical computer science: limits of quantum computing, complexityclasses
- Quantum computers and programming: goals and challenges, decoherence, physical realizations, quantum annealing, adiabatic quantum computing
- Applications: quantum machine learning, quantum cryptography, quantum information theory

Teaching Methods

- Lectures
- Seminars
- Discussion of research papers and recent news
- Coursework and case studies, including laboratory problems

Recommended Literature

- P. Glauner and P. Plugmann (Eds.), "Innovative Technologies for Market Leadership: Investing in the Future", Springer, 2020.
- N. S. Yanofsky and M. A. Mannucci, "Quantum Computing for Computer Scientists", Cambridge University Press, 2008.

AIN-B-18 Key Competencies 3

Module code	AIN-B-18
Module coordination	Prof. Dr. Javier Valdes
Course number and name	AIN-B-18 Technology Ethics and Sustainability AIN-B-18 Academic Writing
Lecturer	Prof. Dr. Javier Valdes
Semester	3
Duration of the module	1 semester
Module frequency	annually
Course type	required course
Level	Undergraduate
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	project work, written ex. 60 min.
Duration of Examination	60 min.
Weight	5/210
Language of Instruction	English

Module Objective

The content of the module is divided into two subjects "Technology ethics and sustainability" (subject A) and "Scientific work" (subject B).

Subject A

With the formulation of the Sustainable Development Goals (SDGs) by the United Nations in 2015, there is a comprehensive orientation framework for how humanity should develop in the future and how people's actions and behavior should be evaluated with regard to these development goals. This also applies in particular to technical developments, as it must be constantly checked whether the new technologies meet both ethical and sustainable requirements. In the course of the lectures, the need for sustainable development is linked to the digital transformation of our society and econom. Ethical aspects of technological development are also addressed, with a focus on Artificial Intelligence and associated possible risks: systemic, human, algorithmical and data bias. In addition to an introduction to ethical principles, the ACM Code of Ethics and Professional Conduct (The Code) is discussed.

Professional competences:

o Students understand the role of Artificial Intelligence in sustainable development.
o Students are familiar with the global development goals (SDGs) and are able to evaluate their own behavior and both existing technologies and potential inventions within the framework.
o Students are familiar with ethical principles and requirements in the context of technical innovations and development and can apply these in their studies and later professional activities
o Students are familiar with possible sources of bias in Artificial Intelligence applications and can identify, evaluate and respond to them in their later professional activities

Subject B
"Being able to write academically or technically is a key skill that is crucial for progressing in your studies and career. As a rule, students do not bring these academic writing skills with them from school, but acquire them parallel to their acculturation in the subject."
This quote from the brochure of the Center for University Didactics (DIZ, 2016) shows the content orientation of the module. The content is intended to prepare students for their studies and academic work at an early stage. The course covers everything from the requirements for academic work to the process flow, research methods and quality criteria for academic work.
Students learn how to find suitable scientific literature, how to manage it and how to use it for scientific work (e.g. reading, understanding, citing). In exercises, students practise scientific writing, research data management and scientific data visualization.

Professional competences

o Students are familiar with the requirements and quality criteria of academic work.
o Students develop the process flow of scientific work and the structuring of scientific work.
o Students will be able to work independently in academic work, in particular: research methods, literature reviews, and academic writing.
o Students know the rules for writing student essays and quality criteria for academic work in a student context and are able to apply them.

Applicability in this and other Programs

Applicability of this module in other degree programmes is guaranteed.

The module lays the foundations for the degree program and is linked in particular with the following advanced modules:

CY-B and KI-B: Key qualification 5
CY-B and KI-B: Bachelor module
Degree programs: BA Artificial Intelligence and BA Cyber Security

Entrance Requirements

None

Learning Content

Subject A
o Concepts and definitions of sustainability and sustainable development
o Sustainability models
o Digital transformation and ethical and sustainable aspects
o Artificial intelligence and sustainability
o Ethical foundations
o Bias in artificial intelligence
o Evaluating Artificial Intelligence Applications
o Ethical aspects for computer scientists and programmers
o ACM Code of Ethics and Professional Conduct
o The European Approach to the governance of Artificial Intelligence

Subject B
o Science and research
o Scientific work: Requirements, process and quality criteria
o Literature search, assessment and evaluation
o State of research and theory
o Scientific methods
o Academic writing
o Basics of scientific data visualization
o Preparing a scientific paper

Teaching Methods

Seminar-based teaching with group and team work
Project work
Blended learning

Remarks

For Key Competencies 3, students can choose either courses offered by the faculty or German.

Recommended Literature

Standars and Norms:

VCIO based description of systems for AI trustworthiness characterisation. VDE SPEC 90012. (2023).

Artificial Intelligence Risk Management Framework. AI RMF 1.0. (2023).

Research Articles:

Blondeel, Mathieu, et al. "The geopolitics of energy system transformation: A review." *Geography Compass* 15.7 (2021): e12580.

Cowls, Josh, et al. "The AI gambit: leveraging artificial intelligence to combat climate changeopportunities, challenges, and recommendations." *Ai & Society* (2021): 1-25.

Grober, Ulrich. "Deep roots-a conceptual history of'sustainable development'(Nachhaltigkeit)." Wissenschaftszentrum Berlin für Sozialforschung (WZB). (2007)

Siau, Keng, and Weiyu Wang. "Artificial intelligence (AI) ethics: ethics of AI and ethical AI." *Journal of Database Management (JDM)* 31.2 (2020): 74-87.

Zajko, Mike. "Conservative AI and social inequality: conceptualizing alternatives to bias through social theory." *Ai & Society* (2021): 1047-1056.

Additionally, online resources in the form of podcast, videos, blogs and specialized websites for academic writing will be provide during the course

MMC-02 Advanced Robotics

Module code	MMC-02
Module coordination	Prof. Dr. Stefan Scherbarth
Course number and name	MMC1002 Advanced Robotics
Lecturer	Prof. Dr. Stefan Scherbarth
Semester	1
Duration of the module	1 semester
Module frequency	annually
Course type	required course
Level	postgraduate
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	written ex. 90 min.
Duration of Examination	90 min.
Weighting of the grade	5 out of 90 ECTS
Language of Instruction	English

Module Objective

The contents of the module **Autonomous Systems** enable the students to apply advanced knowledge in robotics based on the basics of robotics. Networking with autonomous systems supports the application-oriented teaching of the methodology and professional competence of robotics.

After completing the Cooperative and Autonomous Systems module, students will be able to

- Develop application-oriented solutions from the acquired methods for autonomous systems with regard to localization, navigation, route planning, obstacle recognition and tracking.
- Analyze and apply robotic methods in a targeted manner

- Using the generated methods in simulation models

Within the module **Autonomous Systems** the following competences are to be taught:

Professional competence:

Professional competencies are acquired in the sub-module Cooperative and autonomous systems:

- Understanding and applying methods of autonomous systems
- Modelling of environmental conditions and vehicle relations
- Apply the methods for the localization of vehicles in space
- Application of methods for obstacle recognition and route planning
- Analysis of control loops for autonomous systems
- Understanding and Applying Denavit-Hartenberg Relationships
- Understanding and applying forward and inverse kinematics
- Application of robot simulations and programming of robots
- Understand and apply the functions for joint collaboration between robots and humans.
- Understanding and applying methods of machine learning, in particular artificial intelligence
- Understanding different approaches to building assembly lines

Methodological competence:

Methodological competencies are acquired in the submodule Cooperative and Autonomous Systems:

- Application of robot programming
- Verification (evaluation) of robot movements
- Application of localization, navigation, route planning, and obstacle detection of autonomous systems
- Application of calculated robot relations in suitable simulation systems

Personal competence:

- Solution of complex robotics topics and their application as autonomous systems

Social competence:

- The students are able to look at autonomous systems and to deepen and use the competences acquired in the module in a prepared way.

Applicability in this and other Programs

The module provides the necessary theoretical knowledge and transfer possibility for the application of autonomous system to provide irrespectively of the mobility platform for different application scenarios. Interfaces to mechatronics, control engineering, electrical engineering and computer science result.

Entrance Requirements

Bachelor's degree in mechatronics, mechanical engineering, electrical engineering, industrial engineering, technical physics or computer science

Learning Content

Within the framework of the lecture " **Advanced Robotics** " knowledge about essential topics of autonomous robot systems will be imparted. The focus is on assistance, service and mobile robots. In this context, guidelines for collaborative robots and mobile robots will be discussed. In addition, robot system architectures and path planning are the topics of the lecture.

The subject " **Autonomous Systems** " deals with in-depth contents of mobile and collaborative robotics. 3D obstacle / object recognition, localization and map generation, as well as navigation and route planning play a decisive role. Cognitive systems, machine learning and artificial intelligence are also addressed.

Teaching Methods

Advanced Robotics and Autonomous Systems

Seminaristic teaching with joint exercises to deepen the theory learned through application

Remarks

The theoretical knowledge acquired by the students can be independently analysed and applied in the topics of the corresponding case study in the MCS-3 module. This intensifies the transfer of knowledge into practice and the targeted deepening of the acquired technical and methodological competencies by recognizing contexts and evaluating them.

Recommended Literature

- Siciliano B., Khatib O.: Handbook of Robotics. Springer.
- Corke P.: Robotics, Vision and Control. Springer.
- Craig J. J.: Introduction to Robotics. Pearson Education.
- Spong M. W.: Robot Modeling and Control. Wiley.
- Siegert H. J., Bocionek S.: Robotik: Programmierung intelligenter Roboter. Springer.
- Brillowski Klaus: Einführung in die Robotik - Auslegung und Steuerung serieller Roboter. Shaker-Verlag.

MET-17 ADVANCED AUTOMATION

Module code	MET-17
Module coordination	Prof. Dr. Werner Bogner
	Automatisierungstechnik (AT)
Course number and name	MET 2109 Advanced Automation
Semester	2
Duration of the module	1 semester
Module frequency	annually
Course type	required course
Level	Postgraduate
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	written ex. 90 min.
Duration of Examination	90 min.
Weight	5/90
Language of Instruction	English

Module Objective

In the subject Advanced Automation students obtain an overview on how programmable logic controllers (PLCs) work, as well as basic hardware and software requirements.
They learn the standardized (IEC61131-3) and manufacturer-specific (TIA Portal) programming options. They learn how to use visualization software for the user interface.
The students acquire the basic competence to understand automated processes in the automotive industry, power plants, chemical industry, building technology and transportation. Thusthe students are able to shape the digital transformation of the industry.

The students achieve the following learning objectives:

Professional Skills

The students are familiar with the concepts and components of a modern automation system including the structure and functionality of industrial communication systems, also with regard to safety and security.
They are able to analyze, classify and solve simple tasks in automation technology.
The students know the requirements of hardware and software for a Programmable

Logic Controller (PLC). They know the structure and the way a PLC operates. They are able create PLC programs. By using visualization software they can demonstrate the processes.

Methodological Skills

The application-oriented knowledge allows the students to compare advantages and disadvantages of the individual industrial bus systems, to examine in contrast the advantages and disadvantages of the individual programming languages to find optimal solutions.

Soft Skills

The students work on problems in a focused and independent way.
They can communicate their solutions both verbally and in writing in appropriate technical language.
They learn from mistakes, can assess and improve their own abilities.
They are able to work actively as a team.

Applicability in this and other Programs

For this degree program:

Compulsory subject within Master-Program Electrical Engineering and Information Technology, key focus automation (AT)

For other degree program:

Master Program: Applied Computer Science

Elective for Master Applied Research in Engineering Sciences

Entrance Requirements

Formally: none

In terms of content: Basic knowledge of automation

Learning Content

1. Function of SPS
    - 1.1. Hardware requirements
    - 1.2. Current embodiments
    - 1.3. Environmental conditions
    - 1.4. Real-time requirements
2. Programming languages

3. Presentation of automation technology with regard to industrial communication
    3.1. ISO / OSI model in industrial communication
    3.2. Automation pyramid
    3.3. Vertical communication
    3.4. Structure and functionality of common comunication systems

Teaching Methods

Seminars with practical experience

Recommended Literature

R. Laubner / P. Göhner: Prozessautomatisierung I. Springer Verlag 1999.
G. Wellenreuther / D. Zastrow: Steuerungstechnik mit SPS, Springer/Vieweg 2015.
G. Wellenreuther: Automatisieren mit SPS - Übersichten und Übungsaufgaben, Springer/
Vieweg 2015.
K. John / M. Tiegelkamp: SPS-Programmierung mit IEC, Springer Verlag 2009.
G. Schnell: Bussysteme in der Automatisierungstechnik, 4. Auflage. Vieweg Verlag 2000.
W. Kriesel / O. Madelung: AS-Interface ? Das Aktuator-Sensor-Interface für die Automation. Hanser Verlag 1999.
M. Popp: Profibus-DP/DPV1, 2. Auflage. Hüthig Verlag 2000.
M. Popp: Das PROFINET IO-Buch: Grundlagen und Tipps für Anwender, 2. Auflage. VDE
Verlag 2010.
Ausbildungsunterlagen der Fa. Siemens: www.siemens.com/global/de/home/unternehmen/nachhaltigkeit/ausbildung/sce.html

MET-16 AUTOMOTIVE AND INDUSTRIAL DRIVE SYSTEMS

Module code	MET-16
Module coordination	Prof. Dr. Nikolaus Müller
	Automatisierungstechnik (AT)
Course number and name	MET 2108 Automotive and Industrial Drive Systems
Semester	2
Duration of the module	1 semester
Module frequency	annually
Course type	required course
Level	Postgraduate
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	written ex. 90 min.
Duration of Examination	90 min.
Weight	5/90
Language of Instruction	English

Module Objective

The module Automotive and Industrial Drive Systems introduces diverse electrical drive systems, teaches the typical methods of control and shows the special requirements in an automotive or industrial environment, respectively. The subject offers an overview over electrical drive systems for industrial applications and in vehicles and introduces further sustainable drive concepts.

The students achieve the following learning objectives:

ystems

power train

ns of a space-vector modulation

sses in batteries and can explain their

They can oppose advantages and disadvantages of an electrical power train to a conventional combustion engine driven car

They can name hybrid vehicle concepts and alternative combustion engines

They can analyze alternative fuels for their applicability in cars

They can assess different power train concepts for their application

Special subject Industrial Electrical Drive Systems

Students understand the structure of a multi-axle motion control system

They master the mathematical methods of a field-oriented description of three-phase electrical machines

They can describe the dynamic behavior of three-phase synchronous and asynchronous machines

They can name different design approaches for speed control systems of electrical drives

They can design speed control systems for electrical drives

Soft Skills

Students work out contents within groups

Applicability in this and other Programs

For this degree program:

Compulsory subject within Master-Program Electrical Engineering and Information Technology, focus automation engineering (AT)

For other degree program:

Elective for Master Applied Research in Engineering Sciences

ive Systems

1.2. Inverter Control with Space Vector Modulation

1.3. Batteries

1.4. Charging Concepts

2. Fual-assisted Electric Cars

2.1. Fuel-Cells

2.2. Hybrid Vehicles

3. Sustainable Combustion Engine Concepts

3.1. Alternative Fuels

3.2. Alternative Combustion Engines

Special subject Industrial Electrical Drive Systems

1. Industiral drives

1.1. General properties

1.2. Energy efficiency classes

1.3. Motion control

1.4. Charging Concepts

2. Dynamic models of electric machines

2.1. Modelling of the dynamic behaviour of electric machines

2.2. Clark / Park transformation

2.3. Dynamic model synchronous machine

2.4. Dynamic model asynchronous machine

3. Closed loop control of electric devices

3.1. General control system design

3.2. Speed control for DC machines

3.3. Control system design for 3~ machines

3.4. Direct torque control

Teaching Methods

Semenaristic lessons, group work

Recommended Literature

R. Jurgen: Electric and Hybrid-Electric Vehicles. SAE international 2011.

J. Beretta: Automotive Electricity. Wiley 2010.

M. Ehsani / Y. Gao / S. Longo/ K. Ebrahimi: Modern Electric, Hybrid Electric and Fuel Cell Vehicle, 3. edition. CRC-Press 2019.

A. Emadi: Advanced Electric Drive Vehicles. CRC-Press 2015.

J. Erjavec: Hybrid Electric & Fuel Cell Vehicles, 2. edition. Delmar 2013.

I. Husain: Electric and Hybrid Vehicles, 2. edition. CRC-Press 2011.

A. Khajepour / S. Fallah / A. Goodarzi: Electric and Hybrid Vehicles. Wiley 2014.

B. Bose: Modern Power Electronics and AC Drives. Prentice Hall 2002.

G. Henneberger: Electrical Machines I. Lecture notes. Technical University Aachen 2002.

R. Dorf / R. Bishop: Modern Control Systems, 13. edition. Pearson Prentice Hall 2017.

Different journals

Application notes

MMC-03 Autonomous Systems

Module code	MMC-03
Module coordination	Prof. Dr. Igor Doric
Course number and name	MMC 1003 Autonomous systems
Lecturer	Prof. Dr. Igor Doric
Semester	1
Duration of the module	1 semester
Module frequency	annually
Course type	required course
Level	postgraduate
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	written ex. 90 min.
Duration of Examination	90 min.
Weighting of the grade	5 out of 90 ECTS
Language of Instruction	English

Module Objective

The contents of the module **Autonomous Systems** enable students to apply advanced knowledge in robotics focusing on the basics of robotics. Networking with autonomous systems supports the application-oriented teaching of the methodology and professional competence of robotics.

After completing the Autonomous Systems module, students will be able to

- Develop application-oriented solutions from the acquired methods for autonomous systems with regard to localization, navigation, route planning, obstacle recognition and tracking;
- Analyze and apply robotic methods in a targeted manner;
- Using the generated methods in simulation models.

Within the module **Autonomous Systems** , the following competences are to be taught:

Professional competence:

- Understanding and applying methods of autonomous systems
- Modelling of environmental conditions and vehicle relations
- Applying the methods for the localization of vehicles in space
- Application of methods for obstacle recognition and route planning
- Analysis of control loops for autonomous systems
- Understanding and applying Denavit-Hartenberg Relationships
- Understanding and applying forward and inverse kinematics
- Application of robot simulations and programming of robots
- Understanding and applying the functions for joint collaboration between robots and humans
- Understanding and applying methods of machine learning, in particular artificial intelligence
- Understanding different approaches to building assembly lines

Methodological competence:

- Application of robot programming
- Verification (evaluation) of robot movements
- Application of localization, navigation, route planning, and obstacle detection of autonomous systems
- Application of calculated robot relations in suitable simulation systems

Personal competence:

- Solution of complex robotics topics and their application as autonomous systems

Social competence:

- Students are able to look at autonomous systems and to deepen and use the competences acquired in the module in a prepared way.

Applicability in this and other Programs

The module provides the necessary theoretical knowledge and transfer possibility for the application of autonomous system to provide irrespectively of the mobility platform for different application scenarios. Interfaces to mechatronics, control engineering, electrical

al engineering, electrical engineering,
mputer science

Learning Content

Within the framework of the module **Autonomous Systems** , students deal with indepth contents of mobile and collaborative robotics. 3D obstacle / object recognition, localization and map generation, as well as navigation and route planning play a decisive role. Cognitive systems, machine learning and artificial intelligence are also addressed.

Teaching Methods

Seminaristic teaching with joint exercises to deepen the theory learned through application

Recommended Literature

- Siciliano B., Khatib O.: Handbook of Robotics. Springer.
- Corke P.: Robotics, Vision and Control. Springer.
- Craig J. J.: Introduction to Robotics. Pearson Education.
- Spong M. W.: Robot Modeling and Control. Wiley.
- Siegert H. J., Bocionek S.: Robotik: Programmierung intelligenter Roboter. Springer.
- Brillowski Klaus: Einführung in die Robotik - Auslegung und Steuerung serieller Roboter. Shaker-Verlag.

LSI-A1 Biomedical Data Analysis

Module code	LSI-A1
Module coordination	Prof. Dr. Melanie Kappelmann-Fenzl
Course number and name	LSI-A1 Biomedical Data Analysis
Original study program	Master Life Science Informatics
Lecturers	Prof. Dr. Philipp Torkler
Duration of the module	1 semester
Module frequency	Annually, winter semester
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 45 hours Virtual learning: 45 hours Total: 150 hours
Type of Examination	Written student research project
Duration of Examination	90 min.
Language of Instruction	English

Module Objective

This interdisciplinary module combines knowledge from the fields of informatics, statistics and molecular biology.
The *Biomedical Data Analysis* module shows the students the practical application of computer-aided biomedical data analysis and enables them to carry it out independently. This module is an interdisciplinary tutorial in which the students perform the NGS data analysis workflow by themselves under professional instruction.
After completing the Biomedical Data Analysis module, students will have obtained the following learning competencies:

Professional competence
After successfully completing the module, students will:
- have learned how to manage NGS data.
- be familiar with file formats and their usage in the different analysis approaches.
- know about common data analysis workflows and be able to interpret and
- visualize the achieved results.

Methodological competence
After successfully completing the module, students will:
- be able to perform quality control on sequencing data.
- be able to perform mapping procedures and understand the differences between various mapping algorithms.
- be able to create genome indices and know the relevance of a reference genome.
- be able to perform NGS data analysis in terms of RNA-Seq data.

Social competence

- Interdisciplinary and interpersonal collaboration when working together in small groups on performing biomedical data analysis.
- Working together with fellow-students in small groups on designing and developing NGS data analysis workflows.
- Team building by interactive working groups.

Applicability in this and other Programs

Master seminar, master thesis

Entrance Requirements

Advantageous: Module LSI-01: Introduction to Informatics and Biomedicine,
Basic knowledge in R, Basic knowledge in Statistics

Learning Content

1 NGS Data- File Formats
2 NGS-Open Sources
3 Reference Genome
4 Mapping
5 Data Analysis- Genomics
  5.1 Variant Calling
6 Data Analysis- Epigenetics
  6.1 ChIP-Seq
  6.2 Methyl-Seq
7 A practical approach: Data Analysis- Transcriptomics
  7.1 Count Table Generation
  7.2 Differential Expression Analysis
  7.3 Differential Exon Usage

Teaching Methods

Tutorial, practical exercises, application examples
The module consists of an interactive theoretical part with blended learning components. Within the tutorial the students use example NGS datasets to perform the biomedical data analysis workflow. In the practical part of the tutorial the students should learn to find solutions to problems independently by discussions and research work.

Remarks

The iLearn teaching and learning platform provides students with additional literature references and learning material to prepare for the lectures.

Recommended Literature

Detailed lecture notes are available online for preparation and follow-up work
- The Biostars Handbook: Bioinformatics Data Analysis Guide; 2019; https://www.biostarhandbook.com/

MMC-04 Case Study Cooperative and autonomous systems

Module code	MMC-04
Module coordination	Prof. Dr. Igor Doric
Course number and name	MMC 1004 Case Study Cooperative and autonomous systems
Lecturer	Prof. Dr. Igor Doric
Semester	1
Duration of the module	1 semester
Module frequency	
Course type	required course
Level	postgraduate
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	Portfolio
Weighting of the grade	5 out of 90 ECTS
Language of Instruction	English

Module Objective

The module "Case Study Cooperative and autonomous Systems" enables students to apply the knowledge acquired in module MCS-2 in the field of cooperative and autonomous systems, to deepen it independently and to work on and analyse subject-relevant application examples in a team.

Professional competence:

- Understanding and applying methods of autonomous systems
- Modelling of environmental conditions and vehicle relations
- Apply the methods for the localization of vehicles in space

- Application of methods for obstacle recognition and route planning
- Analysis of control loops for autonomous systems
- Understanding and Applying Denavit-Hartenberg Relationships
- Understanding and applying forward and inverse kinematics
- Application of robot simulations and programming of robots
- Understand and apply the functions for joint collaboration between robots and humans.
- Understanding and applying methods of machine learning, in particular artificial intelligence
- Understanding different approaches to building assembly lines

Methodological competence:

- Application of robot programming
- Verification (evaluation) of robot movements
- Application of localization, navigation, route planning, and obstacle detection of autonomous systems
- Application of calculated robot relations in suitable simulation systems

Personal competence:

The Case Study Cooperative and Autonomous Systems teaches students how to solve complex robotic problems and how to use them as autonomous systems in groups with distributed tasks. The students learn how to analyze, apply and evaluate a task in relation to autonomous systems.

Social competence:

The students are able to view autonomous systems on the basis of case studies and to deepen and use their competences acquired from the module in group work.

Applicability in this and other Programs

Interfaces to mechatronics, control engineering, electrical engineering and computer science result.

Entrance Requirements

Bachelor's degree in mechatronics, mechanical engineering, electrical engineering,
mputer science

e, the students are supposed to carry out
ependent small subtasks,etc. and work on
search.

- Characteristics of the required control loops of networked systems
- Sensors / actuators for vehicle control
- Localization and Mapping
- Route planning, tracking and obstacle detection
- ...

The case studies are examined as so-called examination papers, i.e. no classical examination.

Teaching Methods

Guided processing of seminar topics in study groups. Accompanying events / presentations depending on the selected topic area.

Remarks

The students learn to analyze and apply theoretical knowledge about the topics of the case study independently. This intensifies the transfer of knowledge into practice and the targeted deepening of the acquired technical and methodological competencies by recognizing contexts and evaluating them.

Recommended Literature

- Siciliano B., Khatib O.: Handbook of Robotics. Springer.
- Corke P.: Robotics, Vision and Control. Springer.
- Craig J. J.: Introduction to Robotics. Pearson Education.
- Spong M. W.: Robot Modeling and Control. Wiley.
- Siegert H. J., Bocionek S.: Robotik: Programmierung intelligenter Roboter. Springer.
- Brillowski Klaus: Einführung in die Robotik - Auslegung und Steuerung serieller Roboter. Shaker-Verlag.

MMC-01 Cyber Physical Systems

Module code	MMC-01
Module coordination	Prof. Dr. Jochen Hiller
Course number and name	MMC 1001 Cyber Physical Systems
Lecturer	Prof. Dr. Jochen Hiller
Semester	1
Duration of the module	1 semester
Module frequency	annually
Course type	required course
Level	postgraduate
Semester periods per week (SWS)	6
ECTS	5
Workload	Time of attendance: 90 hours self-study: 60 hours Total: 150 hours
Type of Examination	written ex. 90 min.
Duration of Examination	90 min.
Weighting of the grade	5 out of 90 ECTS
Language of Instruction	English

Module Objective

Structures and Functions of Cyber-Physical Systems

ystems

nd networked production systems will make
e. At the other end of the spectrum, the
e relevant in the social sphere.

understanding, analysis and recognition
mponents within a cyberphysical system

The development of IT technology has influenced the global business landscape. Customers change from traditional roles, in relation to the company and in interactions with each other in connection with the social networks. Supply chains are being reinvented, setting new standards in terms of time and space. Risk, opportunity, innovation and capital must all be redefined. Simultaneous management within an organisation and coexistence with external ecosystem partners requires new instruments and new attitudes. Business models are being reinvented in a fascinating way. Strategic agility has, to some extent, been forced upon us by the economic situation.

Upon completion of this module, the student has achieved the following learning objectives:

Professional competence:

- Embedded systems and applications;
- Wireless technologies in industry and household;
- Intelligent systems for sensor and actuator applications;
- Concept of IT-controlled business models;
- Factors that determine customer value;
- Barriers and enabling factors for modern business models;

Methodological competence:

- Understanding, analyzing and synthesizing information about Internet technologies of embedded computer systems;
- Communication with suppliers of intelligent system components, such as intelligent sensors and actuators;
- Discussion of important cyber-technical issues, such as the robustness and feasibility of communication interfaces.
- Understanding of different business concepts of cyber-physical systems;
- Identification and analysis of the different forms of technical business solutions;
- Synthesis of customer values;

Personal competence:

- Create simple descriptions of the structure and functions of cyber-phyiscal systems.
- Acquisition and transfer of system terminology
- Construction of simple business models of a cyber-physical system.

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present the overview.
zed business models for different

Applicability in this and other Programs

Structures and Functions of Cyber Physical Systems:

The module provides a basis for embedded system and IT-related modules in all study programs of the Faculty of Applied Natural Sciences and Industrial Engineering;.

New Business Models for Cyber Physical Systems:

Can be used in any other study program in the field of New Economics.

Entrance Requirements

Bachelor's degree in mechatronics, mechanical engineering, electrical engineering or bachelor's degree in industrial engineering, technical physics or computer engineering.

Learning Content

Structures and Functions of Cyber-Physical Systems:

- Design of Embedded Computer Systems
- CPS Applications
- Internet of Things
- Ubiquitous Computing
- Industry 4.0 - Digital Manufacturing
- Sensors and Actuators
- RFID
- IPv4 and IPv6
- International Standard OPC-UA
- Safety

New Business Models of Cyber-Physical Systems:

- Customer Value from the Customer Process
- More Customers and More for the Customer
- Innovation and Personalization
- Silent Commerce
- Examples of New Business Models

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iLearn)

Recommended Literature

Structures and Functions of Cyber-Physical Systems:

- Dietmar P. F. Möller: Guide to Computing Fundamentals in Cyber-Physical Systems; Concepts, Design Methods, and Applications; Springer-Verlag;
- Eva Geisberger/Manfred Broy: Living in a networked world; acatech STUDY 2015;
- Acatech: Cyber-Physical Systems; acatech POSITION PAPER 2011

New Business Models of Cyber-Physical Systems:

- Henning Kagermann: IT Driven Business Models; Global Case Studies in Transformation; Wiley 2011
- Gassmann, Frankenberger: The St. Gallen Business Model Navigator; University of St. Gallen

AIX-M-18 Basics of FPGA SoC Development

Module code	AIX-M-18
Module coordination	Jonas Wühr
Course number and name	AIX-M-18 Basics of FPGA SoC Development
Lecturer	Jonas Wühr
Semester	1
Duration of the module	1 semester
Module frequency	annually
Course type	compulsory course
Level	Postgraduate
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	Portfolio
Weighting of the grade	
Language of Instruction	English

Module Objective

The aim is to gain system understanding of System on Chip (SoC) components combining a FPGA block, a CPU and peripheral components on one chip.
The students learn a basic workflow for developing software and logic for FPGA SoCs and have the chance to apply their knowledge during a comprehensive final project.

Entrance Requirements

Basic VHDL and C programming skills

Learning Content

- Overview of FPGA SoC concepts
- Standardized FPGA component interfaces (AXI4 and DMA)
- Embedded Linux (Yocto, Device Tree)
- Kernel driver development for FPGA SoCs
- FPGA IP core design for SoCs (Design patterns and timing analysis)

Teaching Methods

Seminar based teaching combined with lab sessions

Recommended Literature

[1] Crockett, L.; Elliot, R.; Enderwitz, M.; Stewart, R.: The Zynq Book Embedded Processing with the ARM Cortex-A9 on the Xilinx Zynq-7000 All Programmable SoC, 2014, ISBN: 978-0992978709
[2] Readler, B.: VHDL BY EXAMPLE: A concise introduction for FPGA design, 2014, ISB: 978-0983497356

HPC-M-06 Optimization Methods

Module code	HPC-M-06
Module coordination	Prof. Dr. Peter Faber
Course number and name	HPC-M-06 Optimization Methods
Original study program	Master High Performance Computing / Quantum Computing
Lecturers	Prof. Dr. Peter Faber
Duration of the module	1 semester
Module frequency	annually, winter semester
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	Written student research project
Language of Instruction	English

Module Objective
The students gain an understanding of the construction of modern optimizing compilers and their run-time systems. They understand how certain optimization techniques work, why specific programming patterns may improve performance and others may prohibit optimizations. They are able to apply their knowledge and use appropriate techniques at the appropriate place. Ideally, the students can work on an optimization pass for themselves.

Applicability in this and other Programs
Software design and programming lectures

Entrance Requirements
None

Learning Content
Optimization methods for modern computer architectures are discussed. In particular, theoretical and practical aspects of parallel programming systems for modern high-performance computing systems are highlighted. This includes insights into the inner workings of optimizing compilers and their run-time systems. Optimization methods employed by these compilers are presented and discussed, as well as performance analysis and respective tools.

Teaching Methods
- Lectures, presentations
- lab sessions

- exercises

Recommended Literature

- Klemm, Michael; Cownie, Jim; High Performance Parallel Runtimes -- Design and Implementation. De Gruyter, Oldenbourg. 2021
- Aho; Lam, Monica Sin-Ling; Sethi, Ravi; Ullman, Jeffrey David. Compilers: Principles, Techniques, and Tools (2 ed.). Boston, Massachusetts, USA. Addison-Wesley. 2006
- Further literature as specified during the course

MET-12 SIGNALS AND SYSTEMS IN COMMUNICATION TECHNOLOGY

Module code	MET-12
Module coordination	Prof. Dr. Matthias Wuschek
	Elektronische und nachrichtentechnische Systeme (ENS)
Course number and name	MET 2105 Signals and Systems in Communication Technology
Semester	2
Duration of the module	1 semester
Module frequency	annually
Course type	required course
Level	Postgraduate
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	written ex. 90 min.
Duration of Examination	90 min.
Weight	5/90
Language of Instruction	English

Module Objective

In the module Signals and Systems in Communications Technology the students first deal with important basics of the description of signals in time and frequency domain and get to know the most important characteristics of signals. Furthermore, they become familiar with the essential laws of Fourier Transformation and their significance in signal theory. They then apply this knowledge when it comes to the transmission behavior of LTI systems in time and frequency domain. The last part of the module introduces the basics of analyzing random signals in time and frequency domain, as well as how to describe and determine the transmission behavior of LTI systems in the case of random signals.

The students achieve the following learning objectives:

Professional Skills

The students know and understand important characteristics of signals in time and frequency domain.

The students know the most important laws of Fourier Transformation.

The students know the basic signal transmission behavior of LTI systems in time and frequency domain.

The students know important characteristics of random signals in time and frequency domain (statistical parameters, density and distribution functions, auto and cross correlation function, power spectrum).

The students are familiar with the basic signal transmission behavior of LTI systems in the case of random signals.

Methodological Skills

Students can determine the most important parameters of signals. The students can determine the spectrum of important elementary signals by means of the Fourier Transformation. Students can calculate the transmission behavior of elementary LTI systems in time and frequency domain. The students are able to calculate important characteristics of random signals as well as the transmission behavior of elementary LTI systems with random signals in time and frequency domain. The students have the ability to independently research and develop existing basic knowledge.

Soft Skills

Students are able to reasonably justify and critically evaluate the basic properties of deterministic and random signals as well as of LTI systems in time and frequency domain.

Applicability in this and other Programs

For this degree program:

Compulsory subject within Master-Program Electrical Engineering and Information Technology, focus Electronic and Telecommunication Systems (ENS)

For other degree program:

Master of Applied Computer Science

Elective for Master Applied Research in Engineering Sciences

Entrance Requirements

Formally: none

In terms of content: In the Bachelor Degree Course ET taught knowledge of subject basics ET, mathematics and fundamentals of communications engineering.

Learning Content

2.19. Integration theorem (frequency domain)

2.20. Convolution theorem (time domain)

2.21. Convolution theorem (frequency domain)

3. Basic transmission characteristics of communication systems

3.1. Theoretical classification of communication systems

3.2. Signal transmission behavior of LTI systems in time domain

3.3. Signal transmission behavior of LTI systems in frequency domain

3.4. Low-pass systems

3.5. High-pass systems

3.6. Band-pass Systems

3.7. Runtime systems

4. Random signals

4.1. Introduction

4.2. Momentary value properties of random signals

4.3. Characteristics of random signals in time and frequency domain

4.4. Transmission of random signals via LTI systems

Teaching Methods

Teaching in form of seminars, exercises

Remarks

Support by the e-learning platform

Recommended Literature

J.Prokais / M. Salehi: Communication Systems Engineering, ISBN 0-3130-95007-6

S. Haykin: Communication Systems, ISBN 0-471-17869-1

A. Oppenheim: Signals and Systems, ISBN 0-13-651175-9

Z. Gajic: Linear Dynamic Systems and Signals, ISBN 0-201-61854-0

T. Chon: Statistical Signal Processing, ISBN 1-85233-385-5

MAI-1 Special Mathematical Methods

Module code	MAI-1
Module coordination	Prof. Dr. Thorsten Matje
Course number and name	MAI-1 Special Mathematical Methods
Original study program	Master Applied Computer Science
Lecturers	Prof. Dr. Thorsten Matje
Duration of the module	1 semester
Module frequency	annually, winter semester
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	written ex. 90 min.
Duration of Examination	90 min.
Language of Instruction	English

Module Objective

The students basically deal with methods of probability calculation. They learn the necessary steps to work out independent solutions for corresponding problems in the field of engineering, whereby in particular they are enabled to critically question the selection of the corresponding methods and calculation procedures.

The students achieve the following learning objectives:

Students get to know typical models, methods and tasks from engineering practice, which can be processed with probability theory and statistics, together with corresponding solution methods and strategies. A stochastic way of thinking is anchored.

Professional Skills

The students have knowledge of algebra, analysis and probability theory. In addition, they know the concepts of discrete and continuous random variables. Students are able to work conceptually and methodically. They know the most important discrete and continuous probability distributions and have applied them in practical exercises. In particular, they know the basic assumptions and models behind the individual distributions. They are therefore able to select a suitable probability distribution on the basis of a problem description and to systematically work out the solution on the basis of this distribution. They have the knowledge to interpret data statistically. In summary, the students can apply their acquired knowledge to engineering tasks in a practice-oriented way.

Methodological Skills

Depending on the task, the students are able to identify and successfully apply appropriate calculation methods from a range of calculation methods. They are able to use scientific calculators and probability tables and, if necessary, computer algebra software. The students have the ability to carry out independent research on the basis of extensive exercises and to develop their existing knowledge independently.

Soft Skills

The students are aware of their responsibility as future engineers. They are in a position to discursively question problems among themselves, to justify the solutions argumentatively and to critically evaluate the results of their calculations.

Applicability in this and other Programs

Compulsory subject in Electrical Engineering and Information Technology (Master)
For any other degree programs:
Elective for Master Applied Research in Engineering Sciences
Elective for Master Artificial Intelligence and Data Science

Entrance Requirements

Formally: None

Learning Content

1. Set Theory and Probability
    - 1.1. Set Operations and Venn Diagrams
    - 1.2. Applying Set Theory to Probability
    - 1.3. Relative Frequency, 4-Field-Tableau
    - 1.4. Probability Axioms
    - 1.5. Conditional Probability, Law of Total Probability, Bayes Theorem
    - 1.6. Independent Events
    - 1.7. Sequential Experiments and Tree Diagrams
    - 1.8. Counting Methods (Combinatorics)
    - 1.9. Reliability Problems
2. Discrete Random Variables
    - 2.1. Discrete Random Variable
    - 2.2. Probability Mass Funktion (PMF)
    - 2.3. Cumulative Distribution Function (CDF)
    - 2.4. Averages
    - 2.5. Functions of a Discrete Random Variable
    - 2.6. Derived Random Variables
    - 2.7. Variance and Standard Deviation
    - 2.8. Important Discrete Probability Mass Functions
3. Continuous Random Variables
    - 3.1. Motivation and Overview
    - 3.2. Probability Density Function (PDF)
    - 3.3. Expected Value and Variance in the Continuous Case
    - 3.4. Functions of a Continuous Random Variable
    - 3.5. Special Continuous Probability Distributions

Teaching Methods

Lectures and seminaristic lessons in alternation, solving problems during the lecture and independent extended training of the computing competence on the basis of weekly exercise sheets, detailed solutions to the exercise sheets are each given with a time delay of one week and are to be compared with the own solutions, if questions arise these are clarified in the lecture.

Remarks

The active participation of the students during the lecture and in the processing of the exercise sheets is particularly important through a discursive style. Challenge and encourage is the motto, so that they are catapulted from an initial passive attitude into a mode of activity.

Recommended Literature

- H. Schwarzlander: Probability – Concepts and Theory for Engineers. Wiley 2011.
- J. A. Gubner: Probability and Random Processes for Electrical and Computer Engineers. Cambridge University Press 2006.
- W. W. Hines / D. C. Montgomery / D. M. Goldsman, C. M. Borror: Probability and Statistics in Engineering, 4th ed. Wiley 2003.
- A. Papoulis / S. U. Pillai: Probability, Random Variables, and Stochastic Processes, 4th ed. McGraw-Hill 2002.
- R. D. Yates / D. J. Goodman: Probability and Stochastic Processes: A Friendly Introduction for Electrical and Computer Engineers. Wiley 1998.

MET-15 SPECIAL TOPICS OF CONTACTLESS SENSOR SYSTEMS

Module code	MET-15
Module coordination	Prof. Dr. Martin Jogwich
	Automatisierungstechnik (AT)
Course number and name	MET 2107 Special Topics of Contactless Sensor Systems
Semester	2
Duration of the module	1 semester
Module frequency	annually
Course type	required course
Level	Postgraduate
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	written ex. 90 min.
Duration of Examination	90 min.
Weight	5/90
Language of Instruction	English

Module Objective

The students achieve the following learning objectives:

Professional Skills

Students gain a thorough knowledge and a deep understanding of modern contactless sensors and sensor systems, especially of optical sensors

Methodological Skills

They learn to evaluate different tasks of industrial projects, when contactless measurements can help solving the problem.

The students develop a deep understanding of finding strategies for solving these problems, especially by applying analog and digital image processing techniques.

Soft Skills

The students learn to apply these strategies successfully in special case studies with problems, which they have solve e.g. during their master thesis and their projects in industry jobs.

Applicability in this and other Programs

For this degree program:

Compulsory subject within Master-Program Electrical Engineering and Information Technology, focus automation engineering (AT)

For any other degree program:

Elective for Master Applied Research in Engineering Sciences

Entrance Requirements

Formally: none

In terms of content: Deep knowledge of basic mathematics and its scientific and technical application, in particular trigonometry, coordinate systems, vector analysis, matrix calculus, differential and integral calculus, geometric transformations, fitting and interpolation techniques.
Deep knowledge of basic physics and its scientific and technical application in particular generation, transfer and measurement of electromagnetic radiation, in particular from the visible part of the spectrum.

Learning Content

Basics of sensor principles using geometrical optics (e.g. triangulation, image acquisition and image preprocessing)

Basics of sensor principles using electromagnetic radiation transfer (e.g. time of flight measurement, thicknesss measurement, photometry, fluorescence, interferometry, light barriers and light scanners)

Basics of sensor principles using electromagnetic radiation detection (e.g. photomultiplier, photo sensors, CCD and CMOS sensors)

Case studies of sensor application: Machine vision applications using image acquisition, image preprocessing and image processing

Teaching Methods

Lectures, practical exercise (software workshops), laboratory work

Recommended Literature

C. Demant et al: Industrial Image Processing bzw. Industrielle Bildverarbeitung, Springer.

R. Gonzalez / R. Woods: Digital Image Processing, Prentice Hall.

J. Haus: Optical Sensors, Wiley-VCH.

S. Hesse / G. Schnell: Sensoren für die Prozess- und Fabrikautomation, Vieweg.

A. Hornberg (editor): Handbook of Machine Vision, Wiley-VCH.

B. Jähne: Digital Image Processing bzw. Digitale Bildverarbeitung, Springer.

R. Jain / R. Kasturi, B.G / Schunck: Machine Vision, McGraw-Hill Book Company.

J. Niebuhr / G. Lindner: Physikalische Messtechnik mit Sensoren, Oldenbourg.

M. Petrou / P. Bosdigoianni: Image Processing, John Wiley & Sons.

E. Schiessle: Industriesensorik, Vogel Verlag.

C. Solomon / T. Breckon: Fundamentals of Digital Image Processing.

C. Steger / M. Ulrich / Chr. Wiedemann: Machine Vision Algorithms and Applications, Wiley-VCH.

MET-11 SPECIAL DEVICES AND CIRCUITS

Module code	MET-11
Module coordination	Prof. Dr. Werner Bogner
	Elektronische und nachrichtentechnische Systeme (ENS)
Course number and name	MET 2104 Special Devices and Circuits
Semester	2
Duration of the module	1 semester
Module frequency	annually
Course type	required course
Level	Master
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	written ex. 90 min.
Duration of Examination	90 min.
Weight	5/90
Language of Instruction	English

Module Objective

In the module Special Devices and Circuits the students first deal with the special physical fundamentals of semiconductor technology by the example of special devices with negative differential resistance for high-frequency oscillators. They will also learn about the properties of modern MOS devices and their specific requirements in integrated technology design. Students will learn the necessary steps and peculiarities in IC design as well as the design of basic circuits for highly integrated analog MOS circuits.

The students achieve the following learning objectives:

Professional Skills

The students know and understand the physical fundamentals of modern semiconductor devices.

They know various semiconductor devices with negative differential resistance and can analyze their properties. Students have the ability to apply such devices as high-frequency oscillators.

The students know the structure and understand special properties of integrated MOS circuits. They are able to apply characterization procedures and evaluate the results.

Methodological Skills

The students are able to differentiate the different properties of MOS transistor models by means of simulations. They can apply various basic circuits and circuit components of integrated analog standard CMOS technology and merge them into more complex circuits and evaluate these by means of simulation. The students have the ability to independently research and develop existing basic knowledge.

Soft Skills

The students are able to substantiate and critically evaluate properties of various electronic components and analogue MOS circuits.

Applicability in this and other Programs

For this degree program:

Compulsory subject within Master-Program Electrical Engineering and Information Technology, focus Electronic and Telecommunication Systems (ENS)

For other degree program:

Master of Applied Computer Science

Elective for Master Applied Research in Engineering Sciences

Entrance Requirements

Formally: none

In terms of content: Knowledge acquired in Bachelor degree in the subjects electronic components, circuit technology 1, rf-electronics

Learning Content

1. Introduction
2. Negative Conductance Microwave Devices
   - 2.1. Esaki or tunnel diode
   - 2.2. IMPATT - diode
   - 2.3. Transferred Electron Devices
3. MOSFET
   - 3.1. The ideal MOS-structure

- 3.2. Basic MOSFET behavior
- 3.3. Second order effects
- 3.4. Electrical behavior of short channel MOSFET
- 3.5. Comparison MOSFET - BJT

4. CMOS Technology and Layout Considerations
   - 4.1. Physical structure of MOS-transistor
   - 4.2. Passive Components
   - 4.3. CMOS Considerations
   - 4.4. Layout Considerations
5. Active Device Modeling
   - 5.1. (C)MOS Simple Large-Signal Model (LEVEL 1)
   - 5.2. (C)MOS Small-Signal Model
   - 5.3. Computer Simulation Models
6. Analog CMOS Subcircuits
   - 6.1. MOS Diode / Active Resistor
   - 6.2. Current Sinks and Sources
   - 6.3. Current Mirrors
   - 6.4. Current and Voltage References
   - 6.5. VT Referenced Source or Bootstrap Reference
   - 6.6. Bandgap Reference
7. CMOS Amplifiers
   - 7.1. Inverters
   - 7.2. Differential Amplifier
   - 7.3. Design of CMOS Operational Amplifier
   - 7.4. Output Amplifier

Teaching Methods

Seminar based teaching, simulation examples, exercises

Remarks

Support by the e-learning platform

Recommended Literature

Streetman / Banerjee: Solid State Electronic Devices, 6th edition. Prentice Hall 2006.

Muller / Kamins: Device Electronics for Integrated Circuits, John Wiley&Sons 2003.

Brennan / Brown: Theory of Modern Electronic Semiconductor Devices, John Wiley&Sons 2008.

Sze: Semiconductor Devices, 3rd edition. John Wiley & Sons 2012.

Allen / Holberg: CMOS Analog Circuit Design, 3rd edition. Oxford University Press 2011.

Comer / Comer: Fundamentals of Electronic Circuit Design, John Wiley&Sons 2003.

Razavi: Design of Analog CMOS Integrated Circuits, 2nd edition. McGraw-Hill Education 2016.

MET-10 MODERN RF AND RADIO SYSTEMS

Module code	MET-10
Module coordination	Prof. Dr. Matthias Wuschek
	Elektronische und nachrichtentechnische Systeme (ENS)
Course number and name	ET 2103 Modern RF and Radio Systems
Semester	2
Duration of the module	1 semester
Module frequency	annually
Course type	required course
Level	Postgraduate
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	written ex. 90 min.
Duration of Examination	90 min.
Weight	5/90
Language of Instruction	English

Module Objective

In the module Modern RF and Radio Systems the students first deal with important basics of Radar technology. You will also learn the characteristics and applications of the three basic types of Radar systems (Pulse, CW, FMCW). They then apply this knowledge when it comes to the practical dimensioning of the most important parameters of Radar systems. In addition, they become acquainted with special methods for target tracking and are introduced in methods of Radar signal theory. Finally, they get to know the mode of operation as well as advantages and disadvantages of Phased Array Antennas. The last part of the module introduces the basics of ground-based air navigation systems.

The students achieve the following learning objectives:

Professional Skills

The students know and understand basic processes of Radar technology.

The students know and understand the basic principles of target tracking, Radar signal processing and Phased Array Antennas.

The students are familiar with the functionality of important ground-based radio navigation systems in aviation.

Methodological Skills

Students can select or specify the most suitable Radar systems for specific technical tasks. Students can dimension the most important parameters of Radar systems. The students have the ability to independently research and develop existing basic knowledge.

Soft Skills

Students are able to reasonably justify and critically evaluate the basic characteristics of Radar and aeronautical navigation systems.

Applicability in this and other Programs

For this degree program:

Compulsory subject within Master-Program Electrical Engineering and Information Technology, focus Electronic and Telecommunication Systems (ENS)

For other degree program:

Master of Applied Computer Science

Elective for Master Applied Research in Engineering Sciences

Entrance Requirements

Formally: none

In terms of content: In the Bachelor Degree Course ET taught knowledge of subject basics ET, mathematics and fundamentals of communications engineering.

Learning Content

1. Introduction into the course
2. Radar Technology
    - 2.1. Introduction
    - 2.2. Basics
    - 2.3. Pulse Radar
    - 2.4. CW-Radar
    - 2.5. FMCW-Radar

ASE-11 Wireless and Car2X-Communication

Module code	ASE-11
Module coordination	Prof. Dr. Andreas Kassler
Course number and name	ASE-11 Wireless and Car2X-Communication
Lecturer	Prof. Dr. Andreas Kassler
Semester	2
Duration of the module	1 semester
Module frequency	annually
Course type	required course
Level	postgraduate
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	Portfolio
Weighting of the grade	
Language of Instruction	English

Module Objective

The module learning objective is to understand the fundamental concepts of vehicular networking. Students understand the following concepts and their application:
- explain the principles and limitations of wireless communication with focus on vehicular networking,
- explain important technical aspects of current wireless and vehicular networking technologies,
- explain the principles of medium access control and routing in the context of vehicular networking,
- summarise key functions and principles behind different architectures for wireless and car-2-X communication systems,

- critically evaluate different properties of a car-2-X communication system using vehicular networking simulations.

Entrance Requirements

Students should have basic understanding of computer networks.

Learning Content

The automotive industry is increasingly relying on computer science and wireless communication. The vision of the car of tomorrow is to be fully connected with the environment. Indeed, connected cars have the capabilities to connect not only to the internet but also to other moving cars and infotainment systems. This lecture teaches important concepts from these domains, starting with wireless networks in general (from wireless signal characteristics to propagation of signals and medium access schemes), to wireless network architectures. The lecture then moves to networks of moving cars (from communication technology and system architectures, to the design of advanced traffic information systems, security and safety). Topics include
- Radio signals and propagation
- Coding, modulation, and multiplexing
- Car-2X communication pattern, use cases and requirements
- UMTS, LTE, 5G and their use for car-2X
- 802.11p and WAVE
- IEEE 1609
- ETSI ITS G5
- Broadcast, Geocast, Routing
- Beaconing and Traffic Information systems
- Simulating Car2X systems

Teaching Methods

- Interactive Lectures
- Interactive Exercise Sessions

Recommended Literature

Vehicular Networking by Christoph Sommer and Falko Dressler, published in December 2014 by Cambridge University Press.

Hannes Hartenstein and Kenneth Laberteaux (Eds.), *VANET - Vehicular Applications and Inter-Networking Technologies* , Intelligent Transport Systems, Chichester, United Kingdom, John Wiley & Sons (Wiley), 2010

ASE-11 Wireless and Car2X-Communication

Type of Examination

Portfolio