Description of the degree program

Electronic Automotive and Aerospace Systems (Master)

PO 2

Date: 25.02.2026

Table of contents

Fundamentals of System Engineering

Title	Advanced Control Engineering		
Number	2412390	**Module version**	
Shorttext	ET-IFR-39	**Language**	
Frequency of offer	only in the summer term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	1	**Institution**	Institut für Regelungstechnik
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Markus Maurer
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements	Lecture "Fundamentals of Control Engineering"		
Expected performance/ Type of examination	oral exam (30 minutes) or written exam (60 minutes), depending on number of participants		
Course achievement			

Contents

Continuation and application of linear control theory, meshed control loops, multivariable control, simple nonlinear control systems: two- and three-step controllers, state space equations, state space control, state space, description function, stability criteria for nonlinear control systems.

Objective qualification

After completing the module, students are able to apply advanced control engineering knowledge in the area of multivariable control of linear systems in state space (state controller, observer, disturbance compensation).

Literature

- Lecture notes
- J. Lunze: Regelungstechnik 2, Springer-Verlag, ISBN: 978-3540784623
- O. Föllinger: Nichtlineare Regelungen 1 & 2, Hüthig-Verlag, ISBN: 978-3486245271 & 978-3486225037
- W. Leonhard: Einführung in die Regelungstechnik, Vieweg-Verlag, ISBN: 978-3528535841

Remark

The module can be chosen as an alternative to Systemics.

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Exercise	german
	2,0	Lecture	german

Title	Fundamentals of Electronic Automotive and Aerospace Systems		
Number	2498290	**Module version**	
Shorttext	ET-STDI-29	**Language**	german
Frequency of offer	only in the winter term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	1	**Institution**	Institut für Datentechnik und Kommunikationsnetze
Hours per Week / ECTS	3 / 5,0	**Module owner**	
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examination	Written exam (90 min) or oral exam (30 min)		
Course achievement			

Contents

- Requirements of control systems in high criticality applications, design processes for system electronics, design automation, methods of formal verification
- Space platforms, specific environmental conditions, space-specific aspects of verification and qualification
- System architectures of modern avionics systems, specific requirements and procedures for the development and approval of flight systems
- System architectures of modern vehicle systems, specific requirements and procedures for the development and approval of vehicle systems

Objective qualification

Basic design and analysis methods for electronic systems in automotive engineering, aerospace and aeronautics are initially consolidated so that a common basis is established even for students with different entry requirements. On this basis, knowledge of the fundamental system aspects of electronics in road vehicles, aerospace platforms and flight systems will be acquired, as well as the methods and skills required for the areas of specialization and research within the scope of the Master's thesis. Students are thus enabled to find an adequate introduction to the advanced requirements of the Master's degree course and to the fundamental aspects of the application areas.

Literature

- Brian Bailey, Grant Martin and Andrew Piziali, ESL Design and Verification: A Prescription for Electronic System Level Methodology. Morgan Kaufmann/Elsevier, 2007.
- Fortescue, Stark: Spacecraft Systems Engineering, Wiley, 2011
- Spitzer, C. R. (Editor): Digital Avionics Handbook # Avionics # Development and Implementation. CRC Press, Inc., Boca Raton, Florida, 2007
- Spitzer, C. R. (Editor): Digital Avionics Handbook # Avionics # Elements, Software and Functions. CRC Press, Inc., Boca Raton, Florida, 2007
- M. Krüger: Grundlagen der Kraftfahrzeugelektronik, Hanser Verlag, ISBN: 978-3446414280
- J. Schäuffele, T. Zurawka: Automotive Software Engineering, Vieweg Verlag, ISBN: 978-3834800510
- Bosch: Sicherheits- und Komfortsysteme, Vieweg Verlag, ISBN: 978-3528138752

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture	german
	1,0	Exercise	german

Title	Lab Module		
Number	2498310	**Module version**	
Shorttext	ET-STDI-31	**Language**	german
Frequency of offer	every term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	2	**Institution**	
Hours per Week / ECTS	3 / 10,0	**Module owner**	
Workload (h)	300		
Class attendance (h)	84	**Self studying (h)**	216
Compulsory requirements			
Expected performance/ Type of examination			
Course achievement	Colloquia or protocols as proof of achievement for the selected labs		

Contents

The individual description of the course applies in each case. Supplementary notes and comments in the individual course descriptions must be observed.

Objective qualification

The theoretical knowledge acquired in the lectures is tested, deepened, supplemented and consolidated on the basis of practical applications. Depending on the design and didactic concept, interdisciplinary qualifications are taught or practised. These include, for example, efficient documentation, scientific writing, dialogue and presentation techniques for papers, colloquia and final presentations as well as largely independent preparation and laboratory and project work in a team.
Courses totalling at least 10 credits have to be selected from the list of laboratories/peactical courses.
(Note: see also "Document pool" of the Faculty EITP, Master ElSy)
Laboratories are offered as "Labor" (L), "Übung" (Ü) or "Praktikum" (P). The individual description of the course applies in each case. Supplementary notes and comments in the individual course descriptions must be observed.

Literature

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Related courses

Rules for the choice of courses

Labs totalling 10 CP have to be completed

Compulsory attendance

Name of the course	**SWS**	**Eventtype**	**Language**

	4,0	Laboratory	german
	3,0	Laboratory	german
	4,0	Internship	german
	4,0	Internship	german
	4,0	Internship	german
Literature			
J. Liebeherr und M. El Zarki,: Mastering Networks -An Internet Lab Manual-, Pearson, 2004, ISBN: 0-201-78134-4			
	4,0	Internship	german
	5,0	Internship	german
Literature			
Skript			
	4,0	Laboratory	german
Literature			
- R.O. Duda, P.E. Hart, D.G. Stork: Pattern Classification, Wiley, 2001 - C.M. Bishop: Pattern Recognition and Machine Learning, Springer, 2006 - I. Goodfellow, Y. Bengio, A. Courville: Deep Learning, MIT Press, 2016			
Computer Lab Pattern Recognition	4,0	Laboratory	english german
Literature			
Christopher M. Bishop, Nasser M. Nasrabadi, “Pattern Recognition and Machine Learning”, Springer 2006 Ian Goodfellow, Yoshua Bengio, Aaron Courville, “Deep Learning”, MIT Press 2016			
	2,0	Internship	english german
Literature			
Hinweise zu aktueller Literatur erhalten Sie im Rahmen der Veranstaltung.			
Mobile Computing Lab	4,0	Internship	english german
	4,0	Internship	english german
Automotive Software Engineering Laboratory	3,0	Internship	german

Low-Power Embedded Systems Laboratory	5,0	Laboratory	english
Literature			
Tutorials and example code will be provided on Gitlab. Further literature: - Edward A. Lee and Sanjit A. Seshia: Introduction to Embedded Systems, A Cyber- Physical Systems Approach, Second Edition, MIT Press, ISBN 978- 0-262-53381-2, 2017. - P. Marwedel: Embedded System Design, Springer, ISBN 978- 3-030-60909-2, 2021. - G.C. Buttazzo: Hard Real- Time Computing Systems. Springer Verlag, ISBN 978- 1-4614-0676-1, 2011. - M. Wolf: Computers as Components – Principles of Embedded System Design. Morgan Kaufman Publishers, ISBN 978-0-128-05387-4, 2016. - Avelino J. Gonzalez: Computer Programming in C for Beginners, Springer, ISBN 978-3-030-50752-7, 2020. - Joseph Yiu. The Definitive Guide to ARM® Cortex®-M3 and Cortex®-M4 Processors. Newnes, 2013.			

Laboratory AI safety assurance in automated driving	4,0	Laboratory	german

Laboratory: AI applications in automated driving	4,0	Internship	german

Autonomous Drone Tracking	5,0	Internship	english
Literature			
Tutorials and example codes will be provided on StudIP.			

	5,0	Internship	english german
Literature			
Tutorials and example codes will be provided on StudIP.			

Electronic Systems Engineering

Title	Computer Architecture 1		
Number	2416010	**Module version**	
Shorttext	ET-IDA-01	**Language**	german
Frequency of offer	only in the winter term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 6,0	**Module owner**	Prof. Dr. Selma Saidi
Workload (h)	180		
Class attendance (h)	56	**Self studying (h)**	124
Compulsory requirements			
Expected performance/ Type of examination	Written exam (120 minutes) or oral exam (30 minutes)		
Course achievement			

Contents

- Introduction to computer architecture
- Principles of computer architecture (control, pipelining, memory hierarchy)
- Microprocessors (RISC, ISC)
- Quantitative computer design
- Design of instruction sets

Objective qualification

Students have basic knowledge of modern computer architectures and an understanding of the function of modern computers. With the knowledge they have acquired, they are able to configure computer systems on a component basis and evaluate their performance.

Literature

D. Patterson, J. L. Hennessy, Computer Organization and Design #– The Hardware/Software Interface, Morgan Kaufmann Publishers, ISBN 978-0-12-370606-5 #
W. Stallings, Computer Organization & Architecture, 6. Edition, Prentice Hall, ISBN-13: 978-0-13-035119-7 #
Lecture notes

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	1,0	Exercise	german
	3,0	Lecture	german

Title	Computer Architecture 2 - Embedded Systems		
Number	2416060	**Module version**	
Shorttext	ET-IDA-06	**Language**	german
Frequency of offer	only in the summer term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 6,0	**Module owner**	Prof. Dr. Selma Saidi
Workload (h)	180		
Class attendance (h)	56	**Self studying (h)**	124
Compulsory requirements			
Expected performance/ Type of examination	oral exam (30 minutes)		
Course achievement			

Contents

Specification of digital systems (FSM, statecharts, SDF, ...)

Architectural principles for embedded systems, examples (microcontrollers, digital signal processors)

Implementation:
- Automated circuit synthesis
- Optimising compilers for embedded architectures
- Scheduling in real-time operating systems

Objective qualification

Students will gain an in-depth understanding of the architecture and design of embedded systems. The focus is on formal fundamentals, systematic contexts, algorithms and methods. After completing the module, students will be able to model a given application and specify an adapted computer architecture by means of a hardware-software co-design.

Literature

#- lecture notes
- W. Wolf, Computers As Components
- Principles of Embedded Computing System Design, Morgan Kaufmann Publishers, ISBN 978-0123743978

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	3,0	Lecture	german
	1,0	Exercise	german

Title	Computer Network Engineering		
Number	2416750	**Module version**	
Shorttext	ET-IDA-75	**Language**	german
Frequency of offer	only in the winter term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	1	**Institution**	
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Admela Jukan
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examination	Written exam (90 min.) or oral exam (30 min.)		
Course achievement			

Contents

- #Introduction to the Internet.
- Routing in the Internet.
- The TCP Protocol and its performance evaluation (mathematical foundations).
- #Performance evaluation of communication networks.
- #Introduction to the network security.
- Next generation network architectures and protocols (Software Defined Networks (SDN), MPLS, Ethernet and photonic networks)

Objective qualification

After completing this module, students have basic knowledge about architectures, protocol standards and theory of telecommunication networks as well as computer networks and are familiar with the principles of signaling. The learned principles allow to analyze new protocols and network engineering techniques and to evaluate its performance.

Literature

J. F. Kurose und K. W. Ross, Computer Networking # A Top-Down Approach, 6th ed., Pearson, ISBN-13: 978-0-13-285620-1
L. L. Peterson und B. S. Davie, Computer Networks: A Systems Approach, Morgan Kaufmann Publishers, 2003, ISBN: 1-55860-833-8
W. Stallings, Network Security Essentials, Pearson, ISBN 0-13-238033-1

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture	english
Literature			
• Skript • J. F. Kuruse und K. W. Ross, Computernetze • W. Stallings, Data and Computer Communications			
	1,0	Exercise	english
Literature			
• Skript • J. F. Kuruse und K. W. Ross, Computernetze • W. Stallings, Data and Computer Communications			

Title	New Architecture and Protocols in Communication Networks		
Number	2416760	**Module version**	
Shorttext	ET-IDA-76	**Language**	german
Frequency of offer	only in the summer term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	1	**Institution**	Institut für Datentechnik und Kommunikationsnetze
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Admela Jukan
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examination	Written exam (90 min) or oral exam (30 min)		
Course achievement			

Contents

- Introduction to broadband communication
- Broadband access networks
- Optical Networks
- Control and management of broadband networks
- Wireless broadband networks
- Applications of broadband networks

Objective qualification

After completing this module, students will have in-depth knowledge of architectures and signaling protocols of new architecture and protocols in advanced communication networks, including the access networks, core and backone networks, optical transport networks, wireless networks and virtual private networks, such as data center networks and campus networks. The fundamentals learned enable students to design, analyze and evaluate new protocols, services and network architectures.

Literature

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**

	2,0	Lecture	german
Literature			
Include latest research papers, tutorials and industrial standards			

	1,0	Exercise	german

Title	Advanced Computer Architecture		
Number	2416520	**Module version**	
Shorttext	ET-IDA-52	**Language**	german
Frequency of offer	only in the winter term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	1	**Institution**	Institut für Datentechnik und Kommunikationsnetze
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Selma Saidi
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examination	oral exam (20 min)		
Course achievement			
Contents			
Objective qualification			
Literature			
- J. L. Hennessy & David A. Patterson, "Computer Architecture - A Quantitative Approach (4th rev. Edition)", Academic Press, ISBN 978-0123704900 - additional materials during lectures			

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture	german
	1,0	Exercise	german

Title	Network Security		
Number	2416530	**Module version**	
Shorttext	ET-IDA-53	**Language**	german
Frequency of offer	only in the summer term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	1	**Institution**	Institut für Datentechnik und Kommunikationsnetze
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Admela Jukan
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examination	written exam (90 min) or oral exam (30 min)		
Course achievement			

Contents

- Mathematical foundations of cryptology and information security
- Functions of public and secret key cryptology
- Authentication and data security protocols
- Current applications and standards of IP network security
- Current applications and standards of wireless network security
- Network commerce and payment systems
- Selected current advanced network security topics

Objective qualification

After completing the module, the students are able to use the acquired basic knowledge of current cryptology to design basic crypto systems and assess their level of security.
The students have acquired the ability, by means of the common techniques of protocols and standards of network security, to analyse fundamental features of a security design in current network environments, and apply basic design methods
of network security.

Literature

- W. Adi, lecture notes and exercises
- William Stallings, Network Security Essentials: Applications and Standards, 3rd Edition, Prentice Hall, © 2007, ISBN-10: 0-13-238033-1
- Charlie Kaufman, Radia Perlman, Mike Speciner, Network Security: Private Communication in a Public World (2nd edition), Prentice Hall, 2002, ISBN-10: 0130460192

↑

Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture	german
Literature			
• W. Adi, Vorlesungsfolien und Übungen. William Stallings, Network Security Essentials: Applications and Standards, 3rd Edition, Prentice Hall, © 2007, ISBN-10: 0-13-238033-1 • Charlie Kaufman, Radia Perlman, Mike Speciner, Network Security: Private Communication in a Public World (2nd edition), Prentice Hall, 2002, ISBN-10: 0130460192			
	1,0	Exercise	german

Title	Advanced Topics in Real-Time Embedded Operating Systems		
Number	2416800	**Module version**	
Shorttext	ET-IDA-06	**Language**	english
Frequency of offer	every term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	1	**Institution**	
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Rolf Ernst
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examination	oral exam 30 min.		
Course achievement	presentation or development and documentation of a computer programme		

Contents

- Requirements, design constraints and tradeoffs for real-time embedded systems
- Relevant aspects of operating systems (Multi-Threading, Multi-Core, Synchronization, Mixed-Criticality)
- Relevant aspects of real-time systems (Execution model, scheduling, resource sharing)
- optional: industrial perspective on embedded real-time systems
- overview on existing operating systems for embedded real-time applications
- Schedulability Analysis
- Student talks on topic releated papers

Objective qualification

The students will develop an understanding of the fundamental concepts of real-time embedded operating systems (RTOS) and their most relevant requirements (e.g. temporal predictability and reliability). The students will acquire in-depth knowledge about different design choices associated to RTOS that are currently relevant in the academic and the industrial domain. Moreover, the students will be able to critically reason about the trade-offs associated to the aforementioned design choices, and will be able to identify the conditions under which they could be used for the development of safety-critical applications. Through individual and group work of practical nature the students will learn how to develop and implement certain aspects of RTOS. Moreover the students will acquire a set of skills essential for scientific research and publishing, suich as the abilities to present and critically review scentific publications.

Literature

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**

Title	Electromagnetic Compatibility		
Number	2419120	**Module version**	
Shorttext	ET-IEMV-12	**Language**	german
Frequency of offer	only in the winter term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	1	**Institution**	
Hours per Week / ECTS	3 / 5,0	**Module owner**	Dr. Harald Spieker
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examination	Written exam (60 min) or oral exam (30 min)		
Course achievement			

Contents

- Terms and definitions of EMC
- Sources of interference and disturbance variables, immunity of susceptible devices #
- Coupling mechanisms: galvanic, capacitive, inductive coupling, wave and radiation interference #
- Establishing of EMC by measures at the sources of interference, at the coupling paths and at the susceptible devices; shielding, overvoltage and overcurrent protection #
- Legal basis, product liability, standardization #
- EMC test engineering #
- Electromagnetic compatibility of biological systems

Objective qualification

The students are able to analyze mutual interference and interaction scenarios for electrotechnical and electronic systems and components by emitted interference levels and susceptibilities. The students are able to choose appropriate protection and compatibility measures. The students are able to predict EMC-aspects for the design of facilities and systems at an early stage, as well as to decide on cost-efficient solutions. The students are able to describe the responsibilities for the EMC product safety by the state of standards. The students are able assess the EMC product safety by failure mechanisms.

Literature

- Lecture notes
- Joachim Franz, EMV – Störungssicherer Aufbau elektronischer Schaltungen, Teubner, 2002, ISBN 3-519-00397-X
- Clayton R. Paul, Introduction to Electromagnetic Compatibility, Wiley, 2006, ISBN 0-471-75500-1
- Kenneth L. Kaiser, Electromagnetic Compatibility Handbook, CRC Press, 2005, ISBN 0-8493-2087-9

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Related courses			
Rules for the choice of courses			
Either this module or "Electromagnetic Compatibility with Seminar" can be selected.			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Electromagnetic Compatibility	2,0	Lecture	german
Electromagnetic Compatibility	1,0	Exercise	german

Title	Digital Signal Processing		
Number	2424020	**Module version**	
Shorttext	ET-NT-02	**Language**	german
Frequency of offer	only in the summer term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	1	**Institution**	Institut für Nachrichtentechnik
Hours per Week / ECTS	5 / 8,0	**Module owner**	Prof. Dr. Tim Fingscheidt
Workload (h)	240		
Class attendance (h)	70	**Self studying (h)**	170
Compulsory requirements			
Expected performance/ Type of examination	written exam (120 minutes) or oral exam (30 minutes)		
Course achievement	protocol to the laboratory experiments		

Contents

Discrete-time signals and systems
Fourier transforms for discrete-time signals and systems
Z-transform and applications
Discrete-time IIR filter design
Discrete-time FIR filter design
Discrete Fourier Transform (DFT) and Fast Fourier Transform (FFT)
Basics of multi-rate processing and filter banks

Objective qualification

After completing this module including the computer exercise, students will have basic knowledge on the tools of digital
signal processing in the time and frequency domain and can apply these tools to corresponding problems. In accordance
with the didactic concept of the course and the design of the individual components, general qualifications are imparted or
practiced. As part of the computer exercise and the associated colloquium, these are documentation, interviewing and
presentation techniques as well as teamwork in the lab.

Literature

- Lecture slides
- A.V. Oppenheim, R.W. Schafer, J.R. Buck: "Zeitdiskrete Signalverarbeitung" , Pearson Verlag, 2004
- K.D. Kammeyer, K. Kroschel: "Digitale Signalverarbeitung" , Teubner Verlag, 2002
- A.V. Oppenheim, R.W. Schafer, J.R. Buck: "Discrete Time Signal Processing" , Prentice-Hall, 2004
- H.-W. Schüßler: "Digitale Signalverarbeitung 1" , Springer Verlag, 1994

Remark

German

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture	german
Literature			
• A. V. Oppenheim, R. W. Schafer, J. R. Buck: Zeitdiskrete Signalverarbeitung, Pearson Studium, 2004 • K. D. Kammeyer, K. Kroschel: Digitale Signalverarbeitung, Teubner Verlag, 2002 • A. V. Oppenheim, R. W. Schafer, J. R. Buck: Discrete Time Signal Processing, Prentice Hall, 2004 • H.-W. Schüßler: Digitale Signalverarbeitung, Springer Verlag, 1994			
	2,0	Laboratory	german
Literature			
siehe Vorlesung			
	1,0	Exercise	german
Literature			
siehe Vorlesung			

Title	Coding Theory		
Number	2424420	**Module version**	
Shorttext	ET-NT-42	**Language**	english german
Frequency of offer	only in the summer term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	1	**Institution**	Institut für Nachrichtentechnik
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Thomas Kürner
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination	Oral exam (20 min) or written exam (120 min)		
Course achievement	Colloquium or lab journal		

Contents

- Introduction
- Fundamentals of information theory
- Basics of channel coding
- Single-error-correcting block codes
- Block codes for correcting burst errors
- Convolutional codes
- Special coding techniques

Objective qualification

Upon completion of the module, students will have an understanding of the information-theoretical limits of data transmission and will have acquired knowledge of source and channel coding methods in theory and application. Students will be able to assess the performance of source and channel coding methods and construct simple codes.

Literature

Lecture notes
H.Rohling: Einführung in die Informations- und Codierungstheorie, Teubner
R.Togneri, C.J.S. deSilva: Fundamentals of Information Theory and Coding Design, Chapman&Hall/CRC
H.Schneider-Obermann: Kanalcodierung, Vieweg

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Coding Theory	2,0	Lecture	english german
Literature			
Vorlesungsskript H. Rohling: Einführung in die Informations- und Codierungstheorie, Teubner R. Togneri, C. J. S. de Silva: Fundamentals of Information Theory and Coding Design, Chapman&Hall/CRC H. Schneider-Obermann: Kanalcodierung, Vieweg			
Coding Theory	1,0	Exercise	english german
Literature			
siehe Vorlesung			
Computer exercise on Coding Theory	1,0	Laboratory	english german

Title	Advanced Seminar "Machine Learning"		
Number	2424600	**Module version**	
Shorttext	ET-NT-57	**Language**	german
Frequency of offer	only in the summer term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	1	**Institution**	
Hours per Week / ECTS	2 / 5,0	**Module owner**	Prof. Dr. Tim Fingscheidt
Workload (h)	150		
Class attendance (h)	28	**Self studying (h)**	122
Compulsory requirements			
Expected performance/ Type of examination	Written paper		
Course achievement			

Contents

Changing current research topics in the field of machine learning.

Objective qualification

After completing the module, students will possess advanced skills in writing a scientific paper. In the course of the advanced seminar, current research topics from the area of machine learning are discussed, deepened, and scientifically prepared. The participants will read scientific publications, present them and discuss them jointly. The structure of a scientific conference publication will be covered as well as strategies for the writing of the standard sections of a paper.
This course has a discursive character, therefore regular attendance of the participants is required.

Literature

Literature will be handed out in the seminar

Remark

Basic knowledge of the topics "pattern recognition"/"machine learning" is expected, especially in the field of neural networks and support vector machines.

↑

Related courses

Rules for the choice of courses

Compulsory attendance

Name of the course	SWS	Eventtype	Language

	2,0	Lecture	german
Literature			
Literatur wird im Seminar ausgegeben.			

	0,0	Project	german
Literature			
Literatur wird im Seminar ausgegeben.			

Title	Digital Signal Transmission		
Number	2424660	**Module version**	
Shorttext	ET-NT-66	**Language**	german
Frequency of offer	only in the summer term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	1	**Institution**	
Hours per Week / ECTS	6 / 8,0	**Module owner**	Prof. Dr. Eduard Jorswieck
Workload (h)	240		
Class attendance (h)	84	**Self studying (h)**	156
Compulsory requirements			
Expected performance/ Type of examination	Written exam (180 minutes) or oral exam (30 minutes), depending on number of participants		
Course achievement			

Contents

Part I:
- Deterministic signals in LTI systems
- Fourier transform
- Discrete signals and systems
- Correlation function of deterministic signals
- System theory of low-pass and band-pass systems

Part II:
- Statistical signal processing
- Multiplexing
- Binary transmission with low-pass signals
- Binary transmission with band-pass signals
- Digital modulation

Objective qualification

The students describe signal processing systems by their impulse response or transfer function. They know the fundamental principles of digital communications systems.

Literature

- Proakis, John G., and Masoud Salehi. Digital communications. Vol. 4. New York: McGraw-Hill, 2001.

Remark

First half of the summer semester: Digital Signal Transmission I, second half: Digital Signal Transmission II (4+2 SWS / week). Recommended Recommended prerequisite: module Fundamentals of Information Technology.

↑

Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture	german
Literature			
Ohm, Lüke: Signalübertragung, Springer-Verlag, ISBN 3-540-67768-2 Reimers: Digitale Fernsehtechnik, 2. Aufl., ISBN 3-540-60945-8			
	2,0	Lecture	german
Literature			
Ohm, Lüke: Signalübertragung, Springer-Verlag, ISBN 3-540-67768-2 Reimers: Digitale Fernsehtechnik, 2. Aufl., ISBN 3-540-60945-8			
	1,0	Exercise	german
Literature			
siehe Vorlesung			
	1,0	Exercise	german
Literature			
siehe Vorlesung			

Title	Spoken Language Processing		
Number	2424680	**Module version**	
Shorttext	ET-NT-68	**Language**	german
Frequency of offer	only in the winter term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Tim Fingscheidt
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination	Oral exam 30 minutes or written exam 90 minutes (depending on number of participants)		
Course achievement			

Contents

- Basics of speech production and perception
- Feature extraction
- Hidden Markov models
- Acoustic models and language models
- Automatic speech recognition
- Spoken language systems

Objective qualification

After successful completion of the module, students will be able to classify time series (e.g., speech signals) using hidden Markov modeling. The students acquire all the necessary knowledge to suitably select, design, and evaluate methods and algorithms for automatic speech recognition to solve problems in practice.

Literature

- Lecture slides
- X. Huang, A. Acero, H.-W. Hon: Spoken Language Processing, Prentice Hall, 2001
- B. Pfister, T. Kaufmann: Sprachverarbeitung, Springer, 2008
- A. Wendemuth: Grundlagen der Stochastischen Sprachverarbeitung, Oldenbourg, 2004
- E.G. Schukat-Talamazzini: Automatische Spracherkennung, Vieweg, 1995
- G.A. Fink: Mustererkennung mit Markov-Modellen, Teubner, 2003
- L. Rabiner, B.-H. Juang: Fundamentals of Speech Recognition, Prentice Hall, 1993
- K. Fukunaga: Statistical Pattern Recognition, Academic Press, 1990

Remark

This module from the master's program is also suitable for bachelor students. Basic knowledge of digital signal processing, as e.g. acquired in the module #digital signal processing#, facilitates the understanding of this lecture.

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course	SWS	Eventtype	Language
	2,0	Lecture	english

Literature

- X. Huang, A. Acero, H.-W. Hon: Spoken Language Processing, Prentice Hall, 2001
- B. Pfister, T. Kaufmann: Sprachverarbeitung, Springer, 2008
- A. Wendemuth: Grundlagen der Stochastischen Sprachverarbeitung, Oldenbourg, 2004
- E.G. Schukat-Talamazzini: Automatische Spracherkennung, Vieweg, 1995
- G.A. Fink: Mustererkennung mit Markov-Modellen, Teubner, 2003
- L. Rabiner, B.-H. Juang: Fundamentals of Speech Recognition, Prentice Hall, 1993
- K. Fukunaga: Statistical Pattern Recognition, Academic Press, 1990

	2,0	Seminar	english

Literature

- X. Huang, A. Acero, H.-W. Hon: Spoken Language Processing, Prentice Hall, 2001
- B. Pfister, T. Kaufmann: Sprachverarbeitung, Springer, 2008
- A. Wendemuth: Grundlagen der Stochastischen Sprachverarbeitung, Oldenbourg, 2004
- E.G. Schukat-Talamazzini: Automatische Spracherkennung, Vieweg, 1995
- G.A. Fink: Mustererkennung mit Markov-Modellen, Teubner, 2003
- L. Rabiner, B.-H. Juang: Fundamentals of Speech Recognition, Prentice Hall, 1993
- K. Fukunaga: Statistical Pattern Recognition, Academic Press, 1990

Title	Pattern Recognition		
Number	2424690	**Module version**	
Shorttext	ET-NT-69	**Language**	english german
Frequency of offer	every term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Tim Fingscheidt
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination	Oral exam 30 min. or written exam 90 min.		
Course achievement			

Contents

- Bayesian decision rule
- Quality metrics in pattern recognition
- Supervised learning with parametric distributions
- Supervised learning with non-parametric distributions, classification
- Linear discriminant functions, single-layer perceptron
- Support vector machines (SVMs)
- Multi-layer perceptron, neural networks (NNs)
- Deep learning
- Unsupervised learning, clustering methods

Note: For pattern recognition using hidden Markov models (HMMs), a separate more in-depth module, Spoken Language Processing (ET-NT-68), is offered in the summer semester.

Objective qualification

Upon completion of this module, students gain fundamental knowledge about methods and algorithms for classification of data. They are capable to select the appropriate means for real-world problems, to design a solution and to evaluate it.

Literature

- R.O. Duda, P.E. Hart, D.G. Stork: Pattern Classification, Wiley, 2001
- C.M. Bishop: Pattern Recognition and Machine Learning, Springer, 2006

Remark

Basic knowledge of statistics, such as acquired in the module "Probability Theory and Statistics", facilitates the understanding of the lecture.

↑

Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture	english german
Literature			
- R. O. Duda, P. E. Hart, D. G. Stork: Pattern Classification, Wiley, 2001 - C. M. Bishop: Pattern Recognition and Machine Learning, Springer, 2006			
	2,0	Seminar	english german
Literature			
- Vorlesungsfolien - R. O. Duda, P. E. Hart, D. G. Stork: Pattern Classification, Wiley, 2001 - C. M. Bishop: Pattern Recognition and Machine Learning, Springer, 2006			

Title	Electromagnetic Compatibility in Automotive Systems		
Number	2497050	**Module version**	
Shorttext	ET-IFR-50	**Language**	german
Frequency of offer	only in the summer term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Thomas Form
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination	oral exam or written exam (90 min)		
Course achievement			

Contents

- Electromagnetic environment and protection goals in the automotive sector;
- Sources of interference and coupling mechanisms;
- EMC-compliant power supply, vehicle electrical system architecture and power types;
- Measures to ensure EMC: grounding, shielding and filtering;
- EMC development process and test methods for vehicles and components, for conducted and radiated interference and ESD;
- EMC standards in the automotive sector and statutory EMC requirements;
- Product responsibility and liability

Objective qualification

After completing this module, students will have basic knowledge of typical sources and sinks of electromagnetic interference in motor vehicles and will be familiar with the principles of coupling mechanisms of interference in the electrical system of a motor vehicle. The basics they have learned enable them to independently select basic EMC protection measures, analyse and evaluate their effectiveness and select and apply common procedures for testing EMC.

Literature

- M.I. Montrose; EMC and the printed Circuit Board - Design, Theory, and Layout made simple, IEEE-Press, ISBN: 978-0780347038
- V.P. Kodali; Engineering Electromagnetic Compatibility - Principles, Meassurements, and Technologies, IEEE-Press, ISBN: 978-0780347434

↑

Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture	german
Literature			
• M. I. Montrose, EMC and the printed Circuit Board - Design, Theory, and Layout made simple, IEEE-Press • V. P. Kodali; Engineering Electromagnetic Compatibility - Principles, Measurements, and Technologies, IEEE-Press			
	1,0	Exercise	german
Literature			
• M. I. Montrose, EMC and the printed Circuit Board - Design, Theory, and Layout made simple, IEEE-Press • V. P. Kodali; Engineering Electromagnetic Compatibility - Principles, Measurements, and Technologies, IEEE-Press			
	1,0	Excursion	german
Literature			
• M.I. Montrose, EMC and the printed Circuit Board - Design, Theory, and Layout made simple, IEEE-Press, ISBN: 978-0780347038 • V.P. Kodali; Engineering Electromagnetic Compatibility - Principles, Measurements, and Technologies, IEEE-Press, ISBN: 978-0780347434			

Title	Advanced Networking 1		
Number	4213360	**Module version**	V2
Shorttext	INF-KM-36	**Language**	english
Frequency of offer	only in the winter term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	Institut für Betriebssysteme und Rechnerverbund
Hours per Week / ECTS	0 / 5,0	**Module owner**	Prof. Dr. Lars Wolf
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examination	1 examination: oral examination, 20 minutes or take-home exam		
Course achievement	1 course achievement: 2-4 short presentations, depending on complexity		
Contents			
New topics in Computer Networks			
Objective qualification			
On completion of this module, the students have a deep understanding of recent advances and research trends in the area of computer networking.			
Literature			
aktuelle Literatur wird in der Veranstaltung bekanntgegeben			

↑

Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	3,0	Seminar	english
Literature			
Current literature will be announced in the course			

Title	Advanced Networking 2		
Number	4213370	**Module version**	V2
Shorttext	INF-KM-37	**Language**	english
Frequency of offer	only in the summer term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	Institut für Betriebssysteme und Rechnerverbund
Hours per Week / ECTS	0 / 5,0	**Module owner**	Prof. Dr. Lars Wolf
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examination	1 examination: oral examination, 20 minutes or take-home exam		
Course achievement	1 course achievement: 2-4 short presentations, depending on complexity		
Contents			
More advanced new topics of the Computer Networks			
Objective qualification			
On completion of this module, the students have a deep understanding of recent advances and research trends in the area of computer networking.			
Literature			
aktuelle Literatur wird in der Veranstaltung bekanntgegeben			

↑

Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Advanced Networking 2 Seminar	2,0	Seminar	english
Literature			
will be announced in the seminar			
	1,0	Colloquium	english

Title	Computer Networks 1		
Number	4213330	**Module version**	V2
Shorttext	INF-KM-33	**Language**	german
Frequency of offer	only in the summer term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	Institut für Betriebssysteme und Rechnerverbund
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Lars Wolf
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination	1 graded work: Written exam (90 minutes) or Take-Home-Exam.		
Course achievement			

Contents

- Historical classification
- Overview of networks and protocols
- Layer models and layers
- Protocol mechanisms
- Brief introduction to Internet protocols

Objective qualification

After completing this module, students will have a basic understanding of how computer networks work.
- They will be able to describe how processes in computer networks work.
- Furthermore, students will have gained a fundamental understanding of the effects of distribution and communication through networks and how to deal with them.

Literature

Andrew Tanenbaum, David Wetherall, Nick Feamster, Computer Networks, 6.Ed. 2021, Print-ISBN: 978-1-292-37406-2, E-ISBN: 978-1-292-37401-7
James Kurose, Keith Ross. Computer Networking. A Top-Down Approach, 2021, 8th edition, Print-ISBN: 978-1-292-40546-9, E-ISBN: 978-1-292-40551-3.

↑

Related courses

Rules for the choice of courses

Compulsory attendance

Name of the course	**SWS**	**Eventtype**	**Language**

Computer Networks	4,0	Lecture/Exercise	german
Literature			
- Andrew S. Tanenbaum; David J. Wetherall: Computer Networks. International Edition. 5th edition. Pearson, 2010. ISBN-10: 0132553171 / ISBN-13: 9780132553179 - James F. Kurose; Keith W. Ross: Computer Networking: A Top-Down Approach. International Edition. 6th edition. Pearson, 2012. ISBN-10: 0273768964 / ISBN-13: 9780273768968			

Title	Computer Networks 2		
Number	4213390	**Module version**	V2
Shorttext	INF-KM-39	**Language**	english german
Frequency of offer	only in the winter term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	Institut für Betriebssysteme und Rechnerverbund
Hours per Week / ECTS	0 / 5,0	**Module owner**	Prof. Dr. Lars Wolf
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Recommended requirements	INF 2230 (Computer Networks) or equivalent knowledge		
Expected performance/ Type of examination	1 graded work: Written exam (90 minutes) or oral exam (20 minutes) or Take-Home-Exam.		
Course achievement			

Contents

- Internet protocols
- IP
- TCP
- Routing methods
- Newer protocols and methods

Objective qualification

On completion of this module, students will have deepened their knowledge from the course 'Computer Networks 1'. They will be familiar with the processes used on the Internet and the procedures involved.

Literature

Andrew Tanenbaum, David Wetherall, Nick Feamster, Computer Networks, 6.Ed. 2021, Print-ISBN: 978-1-292-37406-2, E-ISBN: 978-1-292-37401-7
James Kurose, Keith Ross. Computer Networking. A Top-Down Approach, 2021, 8th edition, Print-ISBN: 978-1-292-40546-9, E-ISBN: 978-1-292-40551-3.

↑

Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	4,0	Lecture/Exercise	english
Literature			
- Andrew S. Tanenbaum; David J. Wetherall: Computer Networks. International Edition. 5th edition. Pearson, 2010. ISBN-10: 0132553171 / ISBN-13: 9780132553179 - James F. Kurose; Keith W. Ross: Computer Networking: A Top-Down Approach. International Edition. 6th edition. Pearson, 2012. ISBN-10: 0273768964 / ISBN-13: 9780273768968			
	2,0	Exercise	english

Title	Software Quality 1		
Number	4220390	**Module version**	V2
Shorttext	INF-SSE-39	**Language**	german
Frequency of offer	only in the summer term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	Institut für Softwaretechnik und Fahrzeuginformatik
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Ina Schaefer
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination	graded work: written exam, 90 minutes, or oral exam, 30 minutes or Take-Home-Exam.		
Course achievement			

Contents

1. Fundamental Basics (introduction, definition of terms, principles of software testing, general testing process, psychology of testing)

2. Testing in the software life cycle (general V-model, component testing, integration testing, system testing, acceptance testing, testing new product versions, overview of test types)

3. Static testing (structured group testing, static analysis, metrics)

4. Dynamic testing (black box testing, white box testing, experience-based testing)

5. Testmanagement (test organization and planning, economic aspects, testing strategies, test progress monitoring and control, failure management, requirements for the configuration management)

6. Testing tools (types, selection, introduction)

Objective qualification

After completing this module, the students will know the fundamental basics of software testing. They can apply the testing process and master activities and techniques to support it. The students will be able to define test cases in all phases of the software life cycle. They know common testing procedures and methods to efficiently and effectively prepare and execute software tests. The students will know both the underlying theoretical management processes as well as the practical testing tools to automate software testing.

Literature

Basiswissen Softwaretest von A. Spillner und T. Linz

Lehrbuch der Software-Technik (v.a. Bd. 2) von Helmut Balzert

Management und Optimierung des Testprozesses von M.Pol,
Tim Koomen, A. Spillner

Software-Test von Georg Erwin Thaller

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Exercise	english
Software quality 1	4,0	Lecture/Exercise	english german
Literature			
Basiswissen Softwaretest von A. Spillner und T. Linz Lehrbuch der Software-Technik (v.a. Bd. 2) von Helmut Balzert Management und Optimierung des Testprozesses von M.Pol, Tim Koomen, A. Spillner Software-Test von Georg Erwin Thaller			

Title	Software Quality 2		
Number	4220380	**Module version**	V2
Shorttext	INF-SSE-38	**Language**	german
Frequency of offer	only in the winter term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	Institut für Softwaretechnik und Fahrzeuginformatik
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Ina Schaefer
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Recommended requirements	Students must have a basic understanding of the communication mechanisms of distributed systems, the essential diagram types of UML and, above all, an understanding of discrete mathematics (logic, algebra and algebraic specification). Students are expected to actively participate in the lecture by, for example, using their own laptops during lecture/exercise time to develop and implement their own solutions to problems.		
Expected performance/ Type of examination	1 graded work: Written exam (90 minutes) or oral exam (30 minutes) or Take-Home-Exam.		
Course achievement			

Contents

- Fundamental principles of modelling
- Theory of distributed systems
- Simulation of asynchronous communication
- Semantics of models

Objective qualification

After completing the module, students will have gained an in-depth insight into fundamental techniques and methods for developing complex software systems. They will learn formalisms and concepts that enable them to model and analyse individual aspects of complex systems in the form of suitable theories and calculations. These model the interaction of communicating systems and allow for composition and refinement. Building on this, students learn how semantics for modelling languages can be defined and what statements can be derived from them.

Literature

Literature is derived from our own research work.

↑

Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Online-lecture	german
	2,0	Online-exercise	german

Title	software architecture		
Number	4220400	**Module version**	V2
Shorttext	INF-SSE-40	**Language**	german
Frequency of offer	only in the winter term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	Institut für Softwaretechnik und Fahrzeuginformatik
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Ina Schaefer
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination	1 graded work: Written exam (90 minutes) or oral exam (30 minutes) or Take-Home-Exam.		
Course achievement			

Contents

- Architectural patterns
- Design patterns
- Implementation strategies
- Architectural languages
- Modelling architectures
- Evolution of architectures
- Relationship between hardware and software architectures
- Component architecture

Objective qualification

After completing this module, students will have a deep understanding of software architecture. They will be familiar with the problems involved in architectural design and will be able to apply solution strategies that lead to the development of high-quality software architectures.

Literature

Frank Buschmann u.a. "A System Of Patterns" sowie spezifische Literatur zu einzelnen Kapiteln

↑

Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**

	2,0	Lecture	english
	2,0	Exercise	english

Title	Modelbased software engineering		
Number	4220410	**Module version**	V2
Shorttext	INF-SSE-41	**Language**	german
Frequency of offer	only in the summer term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	Institut für Softwaretechnik und Fahrzeuginformatik
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Ina Schaefer
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination	1 graded work: Written exam (90 minutes) or oral exam (30 minutes) or Take-Home-Exam.		
Course achievement			

Contents

- Meta-modelling
- OCL
- Model-to-model transformations
- Model-to-text transformations
- Textual and graphical domain-specific languages
- Variability modelling

Objective qualification

Participants in this course will learn the basic principles of model-based software development. They will be able to independently design and implement a textual or graphical domain-specific modelling language. They will be able to use the language effectively in software development through model-to-model transformations or model-to-text transformations.

Literature

- Th. Stahl, M. Völter, Model-Driven Software Development, Wiley, 2006.

- M. Völter, DSL Engineering, independent publishing, 2013.

↑

Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**

	2,0	Lecture	german
	2,0	Exercise	german

Title	Software Engineering 1		
Number	4220430	**Module version**	V3
Shorttext	INF-SSE-43	**Language**	
Frequency of offer	only in the winter term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	Institut für Softwaretechnik und Fahrzeuginformatik
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Wolf-Tilo Balke
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examination	1 graded work: Written exam (90 minutes) or oral exam (30 minutes) or Take-Home-Exam.		
Course achievement	1 Coursework: 50% of homework assignments must be passed.		

Contents

- Overview of software techniques
- Procedures
- Design, implementation
- Object orientation
- Modelling, UML
- Software/system architectures
- Patterns in software development

Objective qualification

After completing this module, students will have a fundamental understanding of the development of complex software systems. They will be able to comprehend and model the task at hand and translate it into a design.

Literature

- Ian Sommerville: Software Engineering. 7. Aufl. Addison-Wesley, München 2004, ISBN 0-321-21026-3.

- Helmut Balzert: Lehrbuch der Software-Technik, Spektrum Akademischer Verlag, Heidelberg 1996, 1998, 2001, ISBN 3-8274-0480-0.

- J. Ludewig, H. Lichter: Software Engineering - Grundlagen, Menschen, Prozesse, Techniken. 1. Auflage. dpunkt-Verlag, Heidelberg 2006, ISBN 3-89864-268-2

↑

Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture	german
	1,0	Exercise	german

Title	Automotive Software Engineering		
Number	4220450	**Module version**	V2
Shorttext	ET-IFR-35	**Language**	english
Frequency of offer		**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	Institut für Softwaretechnik und Fahrzeuginformatik
Hours per Week / ECTS	5 / 5,0	**Module owner**	
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination	graded work: portfolio or Take-Home-Exam		
Course achievement	non-graded work: all practical tasks must have been successfully completed.		

Contents

- Fundamentals and boundary conditions for software development in the automotive sector
- Modeling techniques
- Development processes and methodology
- quality assurance
- Tools and tool sets
- case studies

Objective qualification

After completing this module, students will know the essential fundamentals and suitable methods and tools for software development in the automotive sector. The students can apply basic software development methods of embedded systems and the techniques for complexity and quality management.

Literature

- J. Schäuffele, Th. Zurawka: Automotive Software Engineering. Vieweg Verlag 2003.
- O. Kindel, M.Friedrich: Softwareentwicklung mit AUTOSAR. Grundlagen, Engineering, Management für die Praxis. dpunkt-Verlag 2009.
- P. Liggesmeyer, D. Rombach (Hrsg.): Software Engineering eingebetteter Systeme. Elsevier 2005.
- W. Zimmermann, R. Schmidgall: Bussysteme in der Fahrzeugtechnik - Protokolle, Standards und Softwarearchitektur. 4. Auflage. Vieweg 2011.

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Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course	SWS	Eventtype	Language
	2,0	Lecture	german

Literature

- O. Kindel, M. Friedrich: Softwareentwicklung mit AUTOSAR. Grundlagen, Engineering, Management für die Praxis, dpunkt.verlag, 2009

- P. Liggesmeyer, D. Rombach (Hrsg.): Software Engineering eingebetteter Systeme, Elsevier, 2005.

- Werner Zimmermann Ralf Schmidgall, Bussysteme in der Fahrzeugtechnik Protokolle, Standards und Softwarearchitektur, 4. Auflage, Vieweg, 2011.

- Schäuffele, Zurawka: Automotive Software Engineering, Vieweg Verlag 2003.

	2,0	Exercise	german

Literature

- O. Kindel, M. Friedrich: Softwareentwicklung mit AUTOSAR. Grundlagen, Engineering, Management für die Praxis, dpunkt.verlag, 2009
- P. Liggesmeyer, D. Rombach (Hrsg.): Software Engineering eingebetteter Systeme, Elsevier, 2005.
- Werner Zimmermann Ralf Schmidgall, Bussysteme in der Fahrzeugtechnik Protokolle, Standards und Softwarearchitektur, 4. Auflage, Vieweg, 2011.
- Schäuffele, Zurawka: Automotive Software Engineering, Vieweg Verlag 2003.

Title	Quantum Communication Networks		
Number	2424000030	**Module version**	
Shorttext		**Language**	english
Frequency of offer	only in the summer term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	1	**Institution**	Institut für Nachrichtentechnik
Hours per Week / ECTS	3 / 6,0	**Module owner**	Dr. Christian Deppe
Workload (h)	180		
Class attendance (h)	42	**Self studying (h)**	138
Compulsory requirements			
Expected performance/ Type of examination	Written exam (60 min) or oral exam (30 min)		
Course achievement			

Contents

- Introduction to the basic concepts of quantum mechanics and quantum systems
- Introduction to quantum information theory
- Protocols for quantum computation and programming
- Introduction to quantum communication networks
- Capacity calculations for entanglement-assisted communication
- Introduction to communication with the help of quantum repeaters

Objective qualification

The students
- know the basics of quantum communication networks
- understand quantum information theory models
- can calculate rate limits of quantum information-theoretical networks
- understand simple protocols for quantum communication networks
- can simulate simple protocols for quantum communication networks
- can independently develop their own protocols for new models

Literature

Bassoli, R., Boche, H., Deppe, C., Ferrara, R., Fitzek, F. H., Janssen, G., & Saeedinaeeni, S. (2021). Quantum communication networks (Vol. 23, pp. 1-213). Berlin/Heidelberg, Germany: Springer.
Bassoli, R., Boche, H., Deppe, C., Ferrara, R., Fitzek, F. H., Janssen, G., & Saeedinaeeni, S. (2023). *Quantenkommunikationsnetze*, Berlin/Heidelberg, Germany: Springer (2023).

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Quantum Communication Networks	2,0	Lecture	english
Quantum Communication Networks	1,0	Exercise	english

Title	VLSI-Lab		
Number	4211490	**Module version**	
Shorttext	INF-EIS-49	**Language**	
Frequency of offer	only in the summer term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Guillermo Payá Vayá
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Recommended requirements	The modules “Hardware-Software-Systems” and “Hardware Praktikum” are recommended as preparation for the laboratory. In addition, the modules “VLSI Design” and “Verification, Validation and Testing of ASIC Designs” are recommended to attend in parallel during the realization of this laboratory.		
Expected performance/ Type of examination			
Course achievement	non-graded work: successful completion of the given tasks; presentation of 30 minutes		

Contents

The Chip Design Laboratory is divided into three successive phases. All phases of the laboratory consist of interactive self-study and seminars. The latter provide students with the knowledge necessary to work on the tasks in small groups in self-study. During the independently organized work in the groups on a defined task (self-study), a research associate of the institute checks the progress and gives assistance if necessary. Phase 0: Chip conception and specification The hardware modules to be implemented in phase 1 are designed and specified in small groups during this phase. This phase is based on the target application to be executed on the hardware. The application as well as the hardware modules in form of a microcontroller, peripheral modules and co-processors are selected and all necessary features of these are summarized and documented in this phase. Phase 1: Module implementation and verification At the beginning of phase 1, the students implement individual hardware modules specified in phase 0, i.e., a microcontroller, peripheral modules and co-processors, in small groups using VHDL. The knowledge from previous courses, which is required for VHDL design and testbenches (with System-C), is refreshed and extended in two seminars. Phase 2: Chip design and prototyping After the module development, different groups perform: • functional verification and emulation using a FPGA evaluation board (in-circuit emulation), • performing a complete ASIC synthesis and back-end flow based on a library of standard cells, and • porting a small application onto the system...

Objective qualification

The Chip-Design-Lab is a practical laboratory for the design of integrated digital circuits. In this laboratory, students design digital circuits using a RISC-V microcontroller with

peripheral modules. During the different phases of the lab, the students design, specify, implement and verify digital circuits with hardware description languages, industrial EDA tools, System-C testbenches and hardware test setups. The qualification goals taught in this laboratory are successful project work in the field of digital circuit design from the specification to the in-circuit test of the designed circuit. The students gain knowledge about project planning, development work and teamwork. At the same time, students acquire specialized knowledge in their own work with used tools and hardware description languages. The goal is the successful and self-developed completion of the project and the exchange of the knowledge gained in teamwork.

Literature

• Rabaey, J. M., Chandrakasan, A. P., & Nikoli#, B. (2003). Digital integrated circuits: a design perspective (Vol. 7). Upper Saddle River, NJ: Pearson Education. • Weste, N. H., & Harris, D. (2015). CMOS VLSI design: a circuits and systems perspective. Pearson Education India. • Brunvand, E. (2010). Digital VLSI chip design with Cadence and Synopsys CAD tools. Addison-Wesley. • Ashenden, P. J. (2010). The designer's guide to VHDL. Morgan Kaufmann. • Ashenden, P. (2008). Digital Design: An Embedded Systems Approach Using VHDL. Morgan Kaufmann. Further references will be announced in the course.

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Related courses

Rules for the choice of courses

Compulsory attendance

Name of the course	SWS	Eventtype	Language
VLSI-Lab	4,0	Internship	english

Literature

• Rabaey, J. M., Chandrakasan, A. P., & Nikoli#, B. (2003). Digital integrated circuits: a design perspective (Vol. 7). Upper Saddle River, NJ: Pearson Education.
• Weste, N. H., & Harris, D. (2015). CMOS VLSI design: a circuits and systems perspective. Pearson Education India.
• Brunvand, E. (2010). Digital VLSI chip design with Cadence and Synopsys CAD tools. Addison-Wesley.
• Ashenden, P. J. (2010). The designer's guide to VHDL. Morgan Kaufmann.
• Ashenden, P. (2008). Digital Design: An Embedded Systems Approach Using VHDL. Morgan Kaufmann.

Further references will be announced in the course.

Title			
Number	4211480	**Module version**	V2
Shorttext	INF-EIS-48	**Language**	
Frequency of offer	only in the winter term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1 Semester	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Guillermo Payá Vayá
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Recommended requirements	The modules “Hardware-Software-Systeme” and “Hardware Praktikum” are recommended as preparation for this course.		
Expected performance/ Type of examination	Graded work (examination): Written exam (90 minutes) or oral exam (30 minutes) or Take-Home-Exam.		
Course achievement			

Contents

- Introduction to VLSI Design
- Fundamentals of CMOS Transistors
- Fabrication and Layout of CMOS Integrated Circuits
- CMOS Circuits (Combinational and Sequential Logic Circuits)
- Design Methodologies
- Issues in Chip Design

Objective qualification

This lecture deals with the design of digital circuits in CMOS technology. The students learn about alternative techniques for the realization of basic circuits as well as their manufacturing and design process. By using practical examples, various forms of implementation of integrated circuits are discussed and current challenges of today's chip development in modern semiconductor technologies are presented. After completing the module, students are able to independently design VLSI chips.

Literature

- D. Harris, N. Weste: "CMOS VLSI Design.", Pearson Education, Inc (2010).
- H. Veendrick: "Nanometer CMOS ICs ", Springer, 2007
- Y. Taur, T. Ning: "Fundamentals of Modern VLSI Devices", Cambridge University Press, 1998
- J.M. Rabaey, A. P. Chandrakasan, and B. Nikoli#; “Digital Integrated Circuits: a Design Perspective”. Vol. 7. Upper Saddle River, NJ: Pearson Education, 2003.
- J. Uyemura: "CMOS Logic Circuit Design", Kluwer Academic Publishers, 1999
- K. Reifschneider: "CAE-gestützte IC-Entwurfsmethoden", Prentice Hall, 1998
- K. Itoh: "VLSI Memory Chip Design", Springer, 2001
- D. Jansen: "Handbuch der Electronic Design Automation", Carl Hanser Verlag, 2002
- R. J. Baker, H. W. Li, D. E. Byce: "CMOS Circuit Design. Layout, and Simulation", IEEE Press 1998
- R. Hunter, T. Johnson: "VHDL", Springer, 2007
- D. Perry: "VHDL", McGraw-Hill, 1998
- P. Ashenden: "The Designers Guide to VHDL", Morgan Kaufmann, 2002

Further references will be announced in the course.

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
VLSI-Design	2,0	Lecture	english
Literature			
- D. Harris, N. Weste: "CMOS VLSI Design.", Pearson Education, Inc (2010). - H. Veendrick: "Nanometer CMOS ICs ", Springer, 2007 - Y. Taur, T. Ning: "Fundamentals of Modern VLSI Devices", Cambridge University Press, 1998 - J.M. Rabaey, A. P. Chandrakasan, and B. Nikoli#; “Digital Integrated Circuits: a Design Perspective”. Vol. 7. Upper Saddle River, NJ: Pearson Education, 2003. - J. Uyemura: "CMOS Logic Circuit Design", Kluwer Academic Publishers, 1999 - K. Reifschneider: "CAE-gestützte IC-Entwurfsmethoden", Prentice Hall, 1998 - K. Itoh: "VLSI Memory Chip Design", Springer, 2001 - D. Jansen: "Handbuch der Electronic Design Automation", Carl Hanser Verlag, 2002 - R. J. Baker, H. W. Li, D. E. Byce: "CMOS Circuit Design. Layout, and Simulation", IEEE Press 1998 - R. Hunter, T. Johnson: "VHDL", Springer, 2007 - D. Perry: "VHDL", McGraw-Hill, 1998 - P. Ashenden: "The Designers Guide to VHDL", Morgan Kaufmann, 2002 Further references will be announced in the course.			
	2,0	Exercise	english

Title	Machine Learning and Its Application in Communications Technology		
Number	2424000000	**Module version**	
Shorttext	ET-NT-0000	**Language**	
Frequency of offer	only in the summer term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	1	**Institution**	Institut für Nachrichtentechnik
Hours per Week / ECTS	3 / 6,0	**Module owner**	Prof. Dr. Eduard Jorswieck
Workload (h)	180		
Class attendance (h)	42	**Self studying (h)**	138
Compulsory requirements			
Expected performance/ Type of examination			
Course achievement			

Contents

- Introduction of basic ideas of neural networks
- Introduction of the basic neural network architecture as well as loss function, gradient descent and optimizer for neural network training
- Setting up a development environment for machine learning with Python and Pytorch
- Hands-on experiment of defining and training of a simple deep neural network
- Introduction of advanced neural network architectures, including convolutional neural network, recurrent neural network, graph neural network and transformers. Understanding why they were invented and how they work
- Introduction of dedicated objective function for unsupervised learning in communications engineering
- Introduction of dedicated neural network architectures for unsupervised learning in communications engineering

Objective qualification

The students
- know the basics of neural network models
- understands the training process with massive data for supervised learning
- can generalize from supervised learning to unsupervised learning
- can implement and train the neural network model with Python and Pytorch for simple tasks
- understands how to consider domain knowledge of communications engineering in designing the neural network architecture and objective
- can optimize the training process if the outcome is not as expected

Literature

Y. C. Eldar, A. Goldsmith, D. Gündüz, H. V. Poor, Machine Learning and Wireless Communications, Cambridge University Press, 2022.
http://cs231n.stanford.edu/2019/

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Machine learning and its application in communications technology	2,0	Lecture	german
Literature			
Y. C. Eldar, A. Goldsmith, D. Gündüz, H. V. Poor, Machine Learning and Wireless Communications, Cambridge University Press, 2022. http://cs231n.stanford.edu/2019/			
Machine learning and its application in communications technology	1,0	Exercise	german
Literature			
Y. C. Eldar, A. Goldsmith, D. Gündüz, H. V. Poor, Machine Learning and Wireless Communications, Cambridge University Press, 2022. http://cs231n.stanford.edu/2019/			

Title	Low-Power Embedded Systems		
Number	2416000000	**Module version**	
Shorttext		**Language**	
Frequency of offer	only in the winter term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	1	**Institution**	Institut für Datentechnik und Kommunikationsnetze
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Andres Gomez
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examination	Written (90 min) or oral exam (30 min)		
Course achievement			

Contents

- An embedded system is some combination of computer hardware and software, either fixed in capability or programmable, that is designed for a specific function or for specific functions within a larger system. For example, they are part of industrial machines, agricultural and process industry devices, automobiles, medical equipment, cameras, household appliances, airplanes, sensor networks, internet-of-things, as well as mobile devices.
- The focus of this lecture is on the design of low-power embedded systems using formal models and utilizing the latest micro-architectural features for improved performance and energy efficiency, with practical examples using C/C++.

Objective qualification

The students
- gain an understanding of specific requirements, issues, and performance evaluations of low-power embedded system applications.
- make design decisions with deep knowledge of the inherent cost-versus-performance trade-offs in low-power, resource-constrained systems.
- apply the principles of real-time operating systems and scheduling theory to design efficient applications with shared resources.
- analyze different architectures, evaluate their hardware-software interface and memory architecture and different optimization techniques for microcontrollers, such as DSP extensions to the instruction set architecture.

Literature

- Edward A. Lee and Sanjit A. Seshia: Introduction to Embedded Systems, A Cyber- Physical Systems Approach, Second Edition, MIT Press, ISBN 978- 0-262-53381-2, 2017.
- P. Marwedel: Embedded System Design, Springer, ISBN 978- 3-030-60909-2, 2021.
- G.C. Buttazzo: Hard Real- Time Computing Systems. Springer Verlag, ISBN 978- 1-4614-0676-1, 2011.
- M. Wolf: Computers as Components – Principles of Embedded System Design. Morgan Kaufman Publishers, ISBN 978-0-128-05387-4, 2016.
- Avelino J. Gonzalez: Computer Programming in C for Beginners, Springer, ISBN 978-3-030-50752-7, 2020.

- Joseph Yiu. The Definitive Guide to ARM® Cortex®-M3 and Cortex®-M4 Processors. Newnes, 2013.

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Low-Power Embedded Systems	2,0	Lecture	english
Literature			
- Edward A. Lee and Sanjit A. Seshia: Introduction to Embedded Systems, A Cyber-Physical Systems Approach, Second Edition, MIT Press, ISBN 978- 0-262-53381-2, 2017. - P. Marwedel: Embedded System Design, Springer, ISBN 978- 3-030-60909-2, 2021. - G. C. Buttazzo: Hard Real-Time Computing Systems. Springer Verlag, ISBN 978- 1-4614-0676-1, 2011. - M. Wolf: Computers as Components – Principles of Embedded System Design. Morgan Kaufman Publishers, ISBN 978-0-128-05387-4, 2016. - Avelino J. Gonzalez: Computer Programming in C for Beginners, Springer, ISBN 978-3-030-50752-7, 2020. - Joseph Yiu. The Definitive Guide to ARM® Cortex®-M3 and Cortex®-M4 Processors. Newnes, 2013.			
Low-Power Embedded Systems	1,0	Exercise	english
Literature			
- Edward A. Lee and Sanjit A. Seshia: Introduction to Embedded Systems, A Cyber-Physical Systems Approach, Second Edition, MIT Press, ISBN 978- 0-262-53381-2, 2017. - P. Marwedel: Embedded System Design, Springer, ISBN 978- 3-030-60909-2, 2021. - G. C. Buttazzo: Hard Real-Time Computing Systems. Springer Verlag, ISBN 978- 1-4614-0676-1, 2011. - M. Wolf: Computers as Components – Principles of Embedded System Design. Morgan Kaufman Publishers, ISBN 978-0-128-05387-4, 2016. - Avelino J. Gonzalez: Computer Programming in C for Beginners, Springer, ISBN 978-3-030-50752-7, 2020. - Joseph Yiu. The Definitive Guide to ARM® Cortex®-M3 and Cortex®-M4 Processors. Newnes, 2013.			

Title	Post Shannon Theory		
Number	2424000040	**Module version**	
Shorttext		**Language**	english
Frequency of offer	only in the winter term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	1	**Institution**	Institut für Nachrichtentechnik
Hours per Week / ECTS	3 / 6,0	**Module owner**	Dr. Christian Deppe
Workload (h)	180		
Class attendance (h)	42	**Self studying (h)**	138
Compulsory requirements			
Expected performance/ Type of examination	Written exam (90 min) or oral exam (30 min), according to number of participants		
Course achievement			

Contents

- Introduction to the basic concepts of Post Shannon Theory
- Introduction to message identification
- Proof techniques for randomized and deterministic encoding
- Protocols with resources (feedback, sensing, common randomness)
- Methods for calculating upper bounds on capacity (resolvability)
- Coding methods for message identification

Objective qualification

The students
- know the basics of post Shannon theory
- understand randomized and deterministic message identification
- can calculate rate limits of Post Shannon models
- understand simple message identification protocols
- can create simple coding for message identification themselves
- can independently develop their own protocols for new models

Literature

Ahlswede, Alexander; Althöfer, Ingo; Deppe, Christian; Tamm, Ulrich (Eds.) Identification and Other Probabilistic Models Rudolf Ahlswede's Lectures on Information Theory 6 Springer-Verlag Series: Foundations in Signal Processing, Communications and Networking, Vol. 16 1st Edition, 2021, ISBN: 978-3-030-65070-4

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Post Shannon Theory	2,0	Lecture	english
Literature			
Ahlswede, Alexander; Althöfer, Ingo; Deppe, Christian; Tamm, Ulrich (Eds.) Identification and Other Probabilistic Models Rudolf Ahlswede's Lectures on Information Theory 6 Springer-Verlag Series: Foundations in Signal Processing, Communications and Networking, Vol. 16 1st Edition, 2021, ISBN: 978-3-030-65070-4			
Post Shannon Theory	1,0	Exercise	english
Literature			
Ahlswede, Alexander; Althöfer, Ingo; Deppe, Christian; Tamm, Ulrich (Eds.) Identification and Other Probabilistic Models Rudolf Ahlswede's Lectures on Information Theory 6 Springer-Verlag Series: Foundations in Signal Processing, Communications and Networking, Vol. 16 1st Edition, 2021, ISBN: 978-3-030-65070-4			

Title	Lighting Engineering		
Number	2413320	**Module version**	
Shorttext	ET-IHT-32	**Language**	german
Frequency of offer	only in the summer term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	1	**Institution**	Institut für Halbleitertechnik
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Andreas Waag
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examination	oral exam (30 min) or written exam (90 min)		
Course achievement			

Contents

The module provides an overview of lighting technology, from the physical principles of light and lighting to the manufacture of light sources, luminaires and the relevant DIN standards. Special focus: Lighting technology and lighting technology for the automotive sector

- Introduction and overview
- The nature of light: physical principles
- The human perception of light
- Production and design of light sources
- Module structure
- Energy balances
- Standardisation
- Applications (lighting technology,
- Automotive Lighting)

[Lighting technology (V)]
The module provides an overview of lighting technology, from the physical principles of light and lighting to the manufacture of light sources and luminaires. After completing the module, students will be able to characterise light sources and illuminants, optimise their efficiency and solve simple lighting technology problems with the help of their parameters.

[Lighting technology (Ü)]

- Introduction and overview
- The nature of light: physical principles
- The human perception of light
- Production and construction of light sources
- Module structure
- Energy balances
- Standardisation

Objective qualification

After completing the module, students will be able to characterise light sources and illuminants, optimise their efficiency and solve simple lighting technology problems with the help of their parameters.
Literature
Lecture notes and slides Hans-Jürgen Hentschel (Hrsg.): Licht und Beleuchtung; Hüthig 2002, ISBN 3-7785-2817-3 Horst Lange (Hrsg.): Handbuch für Beleuchtung; Landsberg 2007, ISBN 978-3-609-75390-4

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture	german
Literature			
Vorlesungsfolien und Kurzskript Hans-Jürgen Hentschel: Licht und Beleuchtung Horst Lange: Handbuch für Beleuchtung			
	1,0	Exercise	german

Title	Hardware Software Codesign		
Number	2416000010	**Module version**	
Shorttext		**Language**	english
Frequency of offer	only in the winter term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	1	**Institution**	Institut für Datentechnik und Kommunikationsnetze
Hours per Week / ECTS	4 / 6,0	**Module owner**	Prof. Dr. Selma Saidi
Workload (h)	180		
Class attendance (h)	56	**Self studying (h)**	124
Compulsory requirements	Basic knowlesge of computer architectures and programming language C		
Expected performance/ Type of examination	1. Written exam (max 180 min) or oral exam (max 40 min) 2. Project work incl. written reports The overall grade is the arithmetic average of the grades of components 1 and 2.		
Course achievement			

Contents

1. Design of mixed Hardware/Software solutions for embedded systems
2. Understanding of design components
3. Understanding of system-level design paradigms
4. HW/SW partitioning
5. Optimization methods
6. Performance analysis measures
7. Evaluation methods
8. Modelling and Performance analysis of safety-critical and real-time embedded systems.

Objective qualification

The students know the basic design of complex electronic systems at high level of abstractions. This includes the optimized partitioning, scheduling and evaluation of mixed hardware and software design solutions dedicated to embedded systems. The students understand about advanced related topics in HW/SW codesign and performance analysis for safety critical and real-time embedded systems. Starting from simple system specification the students can use tools for partitioning, optimization and performance analysis to synthesize the hardware/software system.

Literature

[1] „Specification and Design of Embedded Systems”, D. Gajski, Prentice Hall 1994,
ISBN 0-13-150731-1
[2] „Digitale Hardware/Software Systeme – Synthese und Optimierung“, J. Teich,
Springer Verlag 1997, ISBN 3-540-62433-3

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Hardware Software Codesign	3,0	Lecture	english
Literature			
[1] „Specification and Design of Embedded Systems”, D. Gajski, Prentice Hall 1994, ISBN 0-13-150731-1 [2] „Digitale Hardware/Software Systeme – Synthese und Optimierung“, J. Teich, Springer Verlag 1997, ISBN 3-540-62433-3			
Hardware Software Codesign	1,0	Exercise	english
Literature			
[1] „Specification and Design of Embedded Systems”, D. Gajski, Prentice Hall 1994, ISBN 0-13-150731-1 [2] „Digitale Hardware/Software Systeme – Synthese und Optimierung“, J. Teich, Springer Verlag 1997, ISBN 3-540-62433-3			

Title	Embedded Autonomy		
Number	2416000020	**Module version**	
Shorttext		**Language**	english
Frequency of offer	only in the summer term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	1	**Institution**	Institut für Computer Engineering
Hours per Week / ECTS	4 / 6,0	**Module owner**	Prof. Dr. Selma Saidi
Workload (h)	180		
Class attendance (h)	56	**Self studying (h)**	124
Compulsory requirements			
Expected performance/ Type of examination	1. Written exam (max 90 min) or oral exam (max 30 min) 2. Project work incl. written reports The overall grade is the arithmetic average of the grades of components 1 and 2.		
Course achievement			

Contents

- Requirements on functional safety
- Providing and preserving trustworthiness in Autonomous Systems
- System Architectures and Platforms for Autonomous Systems
- Verification of Autonomous Systems

Objective qualification

The students will get basic knowledge in the platforms used in autonomous systems as well as very recent fields required to the design of safe autonomous systems considering functional and non-functional aspects (e.g. safety, reliability). The students learn to implement simple autonomous systems tasks (Sensor fusion and AI computation which pose special demands on the architectures in order to implement the Perceive - Decide - Act loop) on embedded platforms. The students can balance the performance limitations of the platform against the complexity of tasks and therefore find an optimal utilization of the resources.

Literature

Christopher Rouff: “Autonomous and Autonomic Systems: With Applications to NASA Intelligent Spacecraft Operations and Exploration Systems” (NASA Monographs in Systems and Software Engineering). Springer-Verlag, Berlin, Heidelberg, 2007.
Samuel Kounev, Jeffrey O. Kephart, Aleksandar Milenkoski, and Xiaoyun Zhu: „Self-Aware Computing Systems”. Springer Publishing Company, Incorporated, 1st edition, 2017.
Defense Advanced Research Projects Agency (DARPA). Broad Agency Announcement - Assured Autonomy, August 2017
Selma Saidi, Dirk Ziegenbein, Jyotirmoy V. Deshmukh, Rolf Ernst: “Autonomous Systems Design: Charting a New Discipline”, IEEE Design and Test Magazine 2021.

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Embedded Autonomy	3,0	Lecture	english
Literature			
Christopher Rouff: “Autonomous and Autonomic Systems: With Applications to NASA Intelligent Spacecraft Operations and Exploration Systems” (NASA Monographs in Systems and Software Engineering). Springer-Verlag, Berlin, Heidelberg, 2007. Samuel Kounev, Jeffrey O. Kephart, Aleksandar Milenkoski, and Xiaoyun Zhu: „Self-Aware Computing Systems”. Springer Publishing Company, Incorporated, 1st edition, 2017. Defense Advanced Research Projects Agency (DARPA). Broad Agency Announcement - Assured Autonomy, August 2017 Selma Saidi, Dirk Ziegenbein, Jyotirmoy V. Deshmukh, Rolf Ernst: “Autonomous Systems Design: Charting a New Discipline”, IEEE Design and Test Magazine 2021.			
Embedded Autonomy	1,0	Exercise	english
Literature			
Christopher Rouff: “Autonomous and Autonomic Systems: With Applications to NASA Intelligent Spacecraft Operations and Exploration Systems” (NASA Monographs in Systems and Software Engineering). Springer-Verlag, Berlin, Heidelberg, 2007. Samuel Kounev, Jeffrey O. Kephart, Aleksandar Milenkoski, and Xiaoyun Zhu: „Self-Aware Computing Systems”. Springer Publishing Company, Incorporated, 1st edition, 2017. Defense Advanced Research Projects Agency (DARPA). Broad Agency Announcement - Assured Autonomy, August 2017 Selma Saidi, Dirk Ziegenbein, Jyotirmoy V. Deshmukh, Rolf Ernst: “Autonomous Systems Design: Charting a New Discipline”, IEEE Design and Test Magazine 2021.			

Title	Digital Signal Transmission and Computational Experiments		
Number	2424670	**Module version**	
Shorttext	ET-NT-67	**Language**	german
Frequency of offer	only in the summer term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	1	**Institution**	Institut für Nachrichtentechnik
Hours per Week / ECTS	8 / 10,0	**Module owner**	Prof. Dr. Eduard Jorswieck
Workload (h)	300		
Class attendance (h)	112	**Self studying (h)**	188
Compulsory requirements			
Expected performance/ Type of examination	Oral exam (30 min) or written exam (180 min)		
Course achievement	Colloquium or lab minutes		

Contents

Part I:
- Deterministic signals in LTI systems
- Fourier transform
- Discrete signals and systems
- Correlation function of deterministic signals
- System theory of low-pass and band-pass systems

Part II:
- Statistical signal processing
- Multiplexing
- Binary transmission with low-pass signals
- Binary transmission with band-pass signals
- Digital modulation

Objective qualification

The students describe signal processing systems by their impulse response or transfer function. They know the fundamental principles of digital communications systems.
Practical knowledge and examples in computational experiments.

Literature

- Ohm, Lüke: Signalübertragung, Springer-Verlag, ISBN 3-540-67768-2
- U. Reimers: Digitale Fernsehtechnik, 2.Aufl. 1997, ISBN 3-540-60945-8

Remark

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture	german
Literature			
Ohm, Lüke: Signalübertragung, Springer-Verlag, ISBN 3-540-67768-2 Reimers: Digitale Fernsehtechnik, 2. Aufl., ISBN 3-540-60945-8			
	2,0	Laboratory	german
Literature			
siehe Vorlesung			
	2,0	Lecture	german
Literature			
Ohm, Lüke: Signalübertragung, Springer-Verlag, ISBN 3-540-67768-2 Reimers: Digitale Fernsehtechnik, 2. Aufl., ISBN 3-540-60945-8			
	1,0	Exercise	german
Literature			
siehe Vorlesung			
	1,0	Exercise	german
Literature			
siehe Vorlesung			

Title	AI Engineering		
Number	2424000050	**Module version**	
Shorttext		**Language**	english
Frequency of offer	only in the winter term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	1	**Institution**	Institut für Nachrichtentechnik
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Tim Fingscheidt
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements	Basic knowledge (in theory and practice) in machine learning is required, e.g. from- Mustererkennung / Pattern Recognition (2424102) und im Computerlabor Mustererkennung (2424133).		
Expected performance/ Type of examination	Written exam (120 min) or roal exam (30 min)		
Course achievement	Lab work		

Contents

- Foundation Models
- Prompt Engineering
- Retrieval-Augmented Generation
- Agents
- Finetuning
- Legal and Ethical Aspects
- Building Applications with Foundation Models

Objective qualification

Students are able to explain the structure, functionality, and application of foundation models (large, generally pre-trained AI models) and describe their core components such as tokenization, embeddings, transformer architectures, and training procedures. They can apply methods such as prompt engineering, retrieval-augmented generation, finetuning, and agent systems to adapt AI models to specific tasks. Furthermore, they are able to analyze technical concepts, select appropriate tools, and design and evaluate AI applications while considering legal and ethical frameworks. In the accompanying lab sessions, students implement and experiment with the presented methods in practice, thereby deepening their understanding through hands-on experience.

Literature

- Lecure slides
- Publications on key technologies
- C. Huyen: „AI Engineering“, O‘Reilly Media, 2025

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
AI Engineering	2,0	Lecture	english
Literature			
- Vorlesungsfolien - Publikationen zu Schlüsseltechnologien - C. Huyen: „AI Engineering“, O‘Reilly Media, 2025			
Computer Lab AI Engineering	2,0	Internship	english
Literature			
- Lecure slides - Publications on key technologies - C. Huyen: „AI Engineering“, O‘Reilly Media, 2025			

Title	Verification, Validation and Testing of ASIC Designs		
Number	4211500	**Module version**	
Shorttext	INF-EIS-50	**Language**	english
Frequency of offer	only in the summer term	**Teaching unit**	
Module duration	1	**Institution**	Institut für Theoretische Informatik
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Guillermo Payá Vayá
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination	graded work (examination): oral exam (30 minutes)		
Course achievement			

Contents

1. Einführung in Verifikation, Validierung und Testing 2. Pre-Silicon Verifikation 2.1 Einführung in ASIC Design Verifikation 2.2 Herangehensweisen zu funktionaler Verifikation 2.3 Verifikationswerkzeuge 2.4 Verifikation Strategien 2.5 Design for Reuse 3. Post-Silicon Validierung 3.1 Einführung in ASIC Validierung 3.2 Traditionelle Post-Silicon Validierung (in der Industrie) 3.3 Reversi Test Generation System 4. Run-Time Verifikation 4.1 Motivation für Laufzeit-Verifikation 4.2 Klassifikation von Laufzeit-Verifikationslösungen 4.3 Dynamische Implementierung von Verifikations- Architekturen 4.4 Run-time Verifikation von einfachen Cores 4.5 Hardware Patching Herangehensweisen 5. Testing 5.1 Einführung zu VLSI Testing 5.2 Design for Testability 5.3 Test Generation

Objective qualification

Die Studierenden lernen Techniken zur Verifikation, Validierung und dem Testen von ASIC-Designs kennen. Auf Basis von praktischen Beispielen und aktuellen Entwicklungswerkzeugen werden die Studierenden an Herausforderungen der heutigen Chipentwicklung und dem Testen herangeführt.

Literature

- Wagner and Bertacco (2011): "Post-Silicon and Runtime Verification for Modern Processors" - Wang, Stroud, and Touba (2008): "System-on-Chip Test Architectures: Nanometer Design for Testability" - Mishra and Dutt (2005): "Functional Verification of Programmable Embedded Architectures: A Top-Down Approach" - Haque, Khan, and Michelson (2001): "The Art of Verification with VERA" - Keating and Bricaud (1999): "Reuse Methodology Manual" - Bergeron (2000): "Writing Testbenches. Functional Verification of HDL Models"

Further references will be announced in the course.

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Verification, Validation and Testing of ASIC Designs	4,0	Lecture/Exercise	english
Literature			
- Wagner and Bertacco (2011): "Post-Silicon and Runtime Verification for Modern Processors" - Wang, Stroud, and Touba (2008): "System-on-Chip Test Architectures: Nanometer Design for Testability" - Mishra and Dutt (2005): "Functional Verification of Programmable Embedded Architectures: A Top-Down Approach" - Haque, Khan, and Michelson (2001): "The Art of Verification with VERA" - Keating and Bricaud (1999): "Reuse Methodology Manual" - Bergeron (2000): "Writing Testbenches. Functional Verification of HDL Models" Weitere Referenzen werden in der Veranstaltung bekannt gegeben.			

Title	Memory Systems		
Number	4211460	**Module version**	V2
Shorttext	INF-EIS-46	**Language**	english
Frequency of offer	only in the summer term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Guillermo Payá Vayá
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Recommended requirements	The module “Application-Specific Instruction-Set Processors” is recommended as preparation for this course.		
Expected performance/ Type of examination	Graded work (examination): Written exam (90 minutes) or oral exam (30 minutes) or Take-Home-Exam.		
Course achievement			

Contents

1. Introduction to Memory Systems (Review)
2. Overview on Memory Technology
2.1 Volatile Memories: SRAM, DRAM
2.2 Non-volatile Memories: ROM, Flash Memory, F-RAM, MRAM,...
3. Main Memory: Interfaces, Commands, and Controllers
4. Memory Cache
5. Processing-in-Memory (PIM) / New Data Processing
5.1 Using traditional and 3D-Stacked memories
5.2 Low-latency interfaces

Objective qualification

This course focusses on the main challenges for the design of modern semiconductor storage systems under the aspect of rapidly growing data storage requirements. Current, volatile and non-volatile memory types will be covered from the fundamental semiconductor technology level up to higher levels of system-level abstraction, with a focus on reliability and protection of stored data. Furthermore, Processing-in-Memory Architectures (PIM) based on conventional and 3D-stacked memories are analyzed, taking into account aspects such as low latency and energy consumption.

Literature

• Balasubramonian (2019): "Innovations in the Memory Systems", Morgen & Claypool Publishers
• Hennessy and Patterson (2017): "Computer Architecture. A Quantitative Approach", 6th Edition, Morgan Kaufmann
• Jacob, Ng, and Wang (2008): "Memory Systems: Cache, DRAM, Disk", Morgan Kaufmann "

Further references will be announced in the course.

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Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course	**SWS**	**Eventtype**	**Language**
Memory Systems	2,0	Lecture	english

Literature
- Balasubramonian (2019): "Innovations in the Memory Systems", Morgen & Claypool Publishers - Hennessy and Patterson (2017): "Computer Architecture. A Quantitative Approach", 6th Edition, Morgan Kaufmann - Jacob, Ng, and Wang (2008): "Memory Systems: Cache, DRAM, Disk", Morgan Kaufmann " Further references will be announced in the course.

Memory Systems	2,0	Exercise	english

Title	Advanced FPGA-Design		
Number	4211510	**Module version**	V2
Shorttext	INF-EIS-51	**Language**	english german
Frequency of offer	only in the summer term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1 Semester	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Guillermo Payá Vayá
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Recommended requirements	The courses “Hardware-Software-Systems”, “Digital Circuits Design”, and “Hardware Praktikum” are recommended as preparation for this course.		
Expected performance/ Type of examination	1 graded work: Written exam (90 minutes) or oral exam (30 minutes) or Take-Home-Exam		
Course achievement			

Contents

1. Introduction to Reconfigurable Computing
2. FPGA Basic Architecture (incl. DSP blocks, embedded memories, soft and hard processors) (Review)
3. Additional Architectural Elements of FPGAs (Boundary scan, I/O cells (PLLs), MIG, transceivers, analog-to-digital converters, ...)
4. FPGA Memory Technologies (SRAM, EPROM, Flash, Anti-Fuse, MRAM)
5. High-Performance Circuit Design on FPGAs
6. Dynamic and Partial Reconfiguration Mechanisms (incl. Space-Time FPGAs)
7. Design Tools for FPGAs (incl. VTR)
8. FPGA-Based Applications

Objective qualification

After completing the module, the students know how to design and optimize complex circuits on modern FPGA devices. Moreover, they are capable to efficiently use all the embedded dedicated hardware modules, e.g., DSPs, different embedded memories, I/O high speed interfaces, or analog-to-digital converters. This course makes emphasis on the design of high performance circuits by understanding the FPGA architecture limitations and including dynamic and partial reconfiguration mechanisms. The students will be introduced to emerging reconfigurable logic devices and their use in demanding technical applications.

Literature

- Palchaudhuri, A.; Chakraborty, R.S.; „High Performance Integer Arithmetic Circuit Design on FPGA“, Springer, 2016

- Deschamps, J-P.; Sutter, G.D.; Cantó, E. : „Guide to FPGA Implementation of Arithmetic Functions“, Springer, 2012

- Rodriguez-Andina, J.J.; et. al.: „FPGAs. Fundamentals, Advanced Features, and Applications in Industrial Electronics“, CRC Press, 2017

- Ashenden, P.: "The Designers Guide to VHDL", Morgan Kaufmann, 3rd revised edition, November 2006

- Bergeron, J.: "Writing Testbenches: Functional Verification of HDL Models", Springer-Verlag, 2003

- Betz, V.; Rose, J.; Marquardt, A .: "Architecture and CAD for Deep-Submicron FPGAs", Kluwer, 1999

- Bobda, C.: "Introduction to Reconfigurable Computing", Springer-Verlag, 2007

- Grout, I.: "Digital System Design with FPGAs and CPLDs", Elsevier Science & Technology, 2008

- Hunter, R.; Johnson, T.: "VHDL", Springer-Verlag, 2007

- Meyer-Baese, U.: "Digital Signal Processing with Field Programmable Gate Arrays", Springer-Verlag, 2007

- Rahman, A.: "FPGA based Design and applications", Springer-Verlag, 2008

- Sikora, A.: "Programmierbare Logikbauelemente", Hanser-Verlag, 2001

- Wilson, P.: "Design Recipes for FPGAs", Elsevier Science & Technology, 2007

Further references will be announced in the course

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Related courses

Rules for the choice of courses

Compulsory attendance

Name of the course	SWS	Eventtype	Language
Advanced FPGA-Design	4,0	Lecture/Exercise	english german

Literature

- Palchaudhuri, A.; Chakraborty, R.S.; „High Performance Integer Arithmetic Circuit Design on FPGA“, Springer, 2016 - Deschamps, J-P.; Sutter, G.D.; Cantó, E. : „Guide to FPGA Implementation of Arithmetic Functions“, Springer, 2012 - Rodriguez-Andina, J.J.; et. al.: „FPGAs. Fundamentals, Advanced Features, and Applications in Industrial Electronics“, CRC Press, 2017 - Ashenden, P.: "The Designers Guide to VHDL", Morgan Kaufmann, 3rd revised edition, November 2006 - Bergeron, J.: "Writing Testbenches: Functional Verification of HDL Models", Springer-Verlag, 2003 - Betz, V.; Rose, J.; Marquardt, A .: "Architecture and CAD for Deep-Submicron FPGAs", Kluwer, 1999 - Bobda, C.: "Introduction to Reconfigurable Computing", Springer-Verlag, 2007 - Grout, I.: "Digital System Design with FPGAs and CPLDs", Elsevier Science & Technology, 2008 - Hunter, R.; Johnson, T.: "VHDL", Springer-Verlag, 2007 - Meyer-Baese, U.: "Digital Signal Processing with Field Programmable Gate Arrays", Springer-Verlag, 2007 - Rahman, A.: "FPGA based Design and applications", Springer-Verlag, 2008 - Sikora, A.: "Programmierbare Logikbauelemente", Hanser-Verlag, 2001 - Wilson, P.: "Design Recipes for FPGAs", Elsevier Science & Technology, 2007 (EN) Further references will be announced in the course

Space & Avionics Systems Electronics - Space Systems Electrronics

Title	Solar System Space Missions		
Number	1521050	**Module version**	
Shorttext	PHY-IGeP-05	**Language**	german
Frequency of offer	only in the summer term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	1	**Institution**	
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Joachim Block
Workload (h)	150		
Class attendance (h)	28	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examination	Oral exam (30 min) at the end of the semester		
Course achievement			

Contents

The lecture is emphatically interdisciplinary and is aimed at students from various disciplines. It covers the history of the exploration of the solar system from its historical beginnings to the present day. The focus is on the expansion of the scientific world view through the rapid increase in knowledge about the planets, moons and small bodies of the solar system with the help of space probes. Theories and models dating back to the pre-space age are compared with the iteratively grown knowledge of the real nature of our cosmic environment. The dependence of this advancing knowledge on physical and technical prerequisites, such as the sensor technology on space probes or the achievable autonomy of on-board systems, is discussed, as is the prioritisation of mission objectives based on scientific and social paradigms. An important aspect is the impact that knowledge about our Earth as a habitable planet in this solar system has on human society's self-image. The lecture complements the course offered in the winter semester, Realisation of Large-Scale Physical Projects Using the Example of Space Missions.

Objective qualification

Upon completion of this module, students will have acquired knowledge of the physical and technical requirements for sensor technology on space probes and the achievable autonomy of on-board systems in space travel. The knowledge gained will enable them to understand the prioritisation of objectives for space missions.

Literature

Will be announced in the respective lecture at the begnning.

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Solar System Space Missions	3,0	Lecture/Exercise	german
Literature			
Larson, W. J., J. R. Wertz, Space Mission Analysis and Design, Kluwer, 1996. Ley, W.; Wittmann, K.; Hallmann, W. (Hrsg.): Handbuch der Raumfahrttechnik. 3. völlig neubearb. Aufl., Hanser-Verlag, 2008 Harvey, B.: Europe´s Space Programme. To Ariane and Beyond. Springer-Verlag Berlin Heidelberg New York, 2003			

Title	Advanced Topics in Network Engineering		
Number	2416780	**Module version**	
Shorttext	ET-IDA-78	**Language**	german
Frequency of offer	only in the winter term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	1	**Institution**	Institut für Datentechnik und Kommunikationsnetze
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Admela Jukan
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examination	oral exam (30 min)		
Course achievement			

Contents

• Cross Layer Design
• All-IP networks
• Integration of IP and Optical
• Inter-domain Routing
• Networks for Data Centers, Storage and Grid Computing
• Economics, Standards and Regulations in Telecommunications
• Applications of Networking in Energy, Automation and Health Care
• Research Literature, Papers and Surveys

Objective qualification

Upon completion of this module, students will have in-depth knowledge of the state of the art and future research topics in the field of architectures and protocols in communication networks. The foundations in this class will help students to better understanding the interaction of complex multi-layered and heterogeneous network architectures and to learning how to engineer the network.

Literature

G. Camarillo, M. García-Martín, The 3G IP Multimedia Subsystem (IMS): Merging the Internet and the Cellular Worlds, John Wiley & Sons, 2004, ISBN: 978-0-470-87156-0
F. Travostino, J. Membretti, G. Karmous-Edwards (Eds.), Grid Networks: Enabling Grids with Advanced Communication Technology, John Wiley & Sons, 2006, ISBN: 978-0-470-01748-7
K. M. Sivalingam and T. Znati (Eds), Wireless Sensor Networks, Kluwer Academic Publishers, 2005, ISBN: 978-1-4020-7883-5

Remark

Knowledge of the content of the module Communication Networks are required.

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	1,0	Exercise	english
Literature			
Include latest research papers, tutorials and industrial standards			
	2,0	Lecture	english
Literature			
Include latest research papers, tutorials and industrial standards			

Title	Spaceflight Technology - Missions		
Number	2514040	**Module version**	
Shorttext	MB-ILR-04	**Language**	german
Frequency of offer	every term	**Teaching unit**	Fakultät für Maschinenbau
Module duration	1	**Institution**	Institut für Raumfahrtsysteme
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Simona Silvestri
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Recommended requirements	A basic understanding of physical and mathematical relationships is recommended.		
Expected performance/ Type of examination	1 examination element: Written exam (120 min) or oral exam (45 min)		
Course achievement			

Contents

- Basics of orbital mechanics: equation of motion and Kepler orbits, elliptical orbits, orbit transfers.
- Satellite orbits in space: launch sites and possible orbits, calculation of satellite ground tracks, types of satellite ground tracks.
- Perturbation theories of satellite orbits: perturbations due to perturbing forces components, method of varying the orbital elements as a function of time.
- Perturbations of satellites in Earth orbits: Earth's gravitational potential, technically relevant gravitational perturbations, aerodynamic perturbations, orbital lifetime, perturbation on the geostationary orbit, solar radiation pressure.

Objective qualification

Students can name the orbital elements and describe simple orbits. They can describe the orientation of these orbits in space depending on the launch site and explain the possible inclinations. They can apply this understanding to the calculation of the required launch azimuth taking into account the earth's rotation. They are able to analyze the ground-track of satellite orbits. They can assess the effects of perturbing accelerations on the temporal changes of the orbital elements. They are able to develop algorithms to take into account technically relevant orbit perturbations. The students have knowledge of the physical principles of earthbound satellite orbits under the influence of the most important perturbations. They are able to determine the influence of perturbing forces and uncertainties in the prediction of satellite orbits.

Literature

- D.G. King-Hele, Satellite Orbits in an Atmosphere: Theory and application, Springer, 1 edition (December 31, 1987), ISBN-10: 0216922526.
- Vladimir A. Chobotov, Orbital Mechanics (AIAA Education Series), AIAA (American Institute of Aeronautics & Ast, 3. edition (May 2002), ISBN-10: 1563475375.
- Pedro Ramon Escobal, Methods of Orbit Determination, Krieger Pub Co, 2nd edition (October 1976), ISBN-10: 0882753193.
- David A. Vallado, Fundamentals of Astrondynamics and Applications, Microcosm Press, Hawthorne, CA and Springer, New York, NY, 2007.

- Oliver Montenbruck, Eberhard Gill, Satellite Orbits - Models Methods Applications, Springer-Verlag, Berlin Heidelberg 2000.
- John P. Vinti, Orbital and Celestial Mechanics, in: Progress in Astronautics and Aeronautics, Vol. 177, American Institute of Aeronautics and Astronautics, 1998.

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture	german
	1,0	Exercise	german

Title	Sensors		
Number	2411270	**Module version**	
Shorttext	ET-EMG-27	**Language**	german
Frequency of offer	only in the summer term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	1	**Institution**	Institut für Elektrische Messtechnik und Grundlagen der Elektrotechnik
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Meinhard Schilling
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examination	oral exam (45 min), written exam (120 min) only in case of high numbers of participants		
Course achievement			
Contents			
Objective qualification			
Literature			

- P. Profos und T. Pfeiffer: Handbuch der industriellen Messtechnik (R. Oldenbourg Verlag), ISBN 978-3486225921
- H. Schaumburg: Sensoren (B.G. Teubner Verlag Stuttgart), ISBN 978-3519061250
- J. Hoffmann: Messen nichtelektrischer Größen (VDI Verlag), ISBN 978-3540622314
- J. Hoffmann: Taschenbuch der Messtechnik (Fachbuchverlag Leipzig), ISBN 978-3446219779

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**

	2,0	Lecture	german
Literature			
P. Profos und T. Pfeiffer: Handbuch der industriellen Messtechnik (R. Oldenbourg Verlag) H. Schaumburg: Sensoren (B.G. Teubner Verlag Stuttgart) J. Hoffmann: Messen nichtelektrischer Größen (VDI Verlag) J. Hoffmann: Taschenbuch der Messtechnik (Fachbuchverlag Leipzig)			

	2,0	Exercise	german
Literature			
P. Profos und T. Pfeiffer: Handbuch der industriellen Messtechnik (R. Oldenbourg Verlag) H. Schaumburg: Sensoren (B.G. Teubner Verlag Stuttgart) J. Hoffmann: Messen nichtelektrischer Größen (VDI Verlag) J. Hoffmann: Taschenbuch der Messtechnik (Fachbuchverlag Leipzig)			

Title	Solar Cells		
Number	2413310	**Module version**	
Shorttext	ET-IHT-31	**Language**	german
Frequency of offer	every 2 years in the winter term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	1	**Institution**	Institut für Halbleitertechnik
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Stefanie Kroker
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examination	Oral exam (30 min) or *Klausur+*		
Course achievement			

Contents

The module proves an overview on photovoltaic generation of energy with its physical basics to fabrication of solarcells and application in modules and solar plants.

- Politics of renewable energies
- Physical basics of photovoltaic generation of electricity (sun radiation, absorption of radiation by semiconductors, p-n-junction, I-U-characteristics)
- Fabrication and structure of monocrystalline and multi-crystalline Solar cells
- Thin film solar cells, organic cells, dye cells
- Comparison of the different solar cell concepts
- Dimensioning of solar plants
- Applications

Objective qualification

The students can describe the principles of photovoltaic generation of electricity in solar cells. They can characterize solar cells to optimize their efficiency and configure simple photovoltaic devices using their characteristic parameters and geographic factors.

Literature

- Lecture slides and short script
- H.-G. Wagemann, A. Schmidt: Grundl. d. optoelektron. Halbleiterbauelemente; Teubner Stuttgart 1998 ISBN: 3-519-03240-6
- H.-G. Wagemann, H. Eschrich: Grundl. d. photovoltaischen Energieumwandlung; Teubner Stuttgart 1994 ISBN: 3-519-03218-X

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture	german
Literature			
Vorlesungsfolien H.-G. Wagemann, H. Eschrich: Grundlagen der photovoltaischen Energiewandlung; Teubner Studienbücher, Stuttgart 1994			
	1,0	Exercise	german

Title	Satellite Navigation - Technologies and Applications		
Number	2513060	**Module version**	
Shorttext	MB-IFF-06	**Language**	german
Frequency of offer	only in the winter term	**Teaching unit**	Fakultät für Maschinenbau
Module duration	1	**Institution**	Institut für Flugführung
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Peter Hecker
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examination	1 Examination element: written exam (120 min) or oral exam (30 min)		
Course achievement			

Contents

This Modul imparts a detailed insight into technology, methods and applications of global navigation satellite systems (GNSS) for navigation in general and in special for aviation and telematics. After preparing necessary basics in the field of radio navigation and orbit mechanics, the system concept of satellite navigation is introduced. This also includes the basic principles for the determination of position, velocity and time using satellite navigation. Within this, the used measurements and their corresponding errors are characterized. Based on modern satellite navigation receivers the practical use of satellite navigation for different applications is presented, detailing standalone GNSS positioning as well as integrated systems with complimentary sensors (e.g. GNSS and inertial navigation). Special emphasis is placed on the use of satellite navigation for aviation applications. This includes all phases of flight (departure, en-route, approach, landing and taxi) using different techniques.

Objective qualification

After successful completion of the module, the students have theoretical as well as application-oriented knowledge in the field of satellite navigation. The students are then able to independently carry out position solutions on the basis of real measurement data as well as to analyse and independently solve specific problems in the use of satellite navigation, also in combination with complementary navigation sensors, in various areas of application in aviation or land applications. After completing the module, the students can discuss and assess the technologies of current and planned future flight guidance systems. They can discuss and examine the social, political and economic boundary conditions in the introduction of new systems.

Literature

- Parkinson, B., Spilker, J., et al., Global Positioning System # Theory and Applications, Volumes I+II, AIAA, 1996
- Mansfeld, W, Satellitenortung und Navigation # Grundlagen und Anwendung globaler Satellitennavigationssysteme Seeber, Günter: Satellitengeodesie, 2. Auflage / Satellite Geodesy 2nd Edition, de Gruyter, 2003
- Hofmann-Wellenhof, B. et al., Navigation # Principles of Positioning and Guidance, Springer, 2003
- Hofmann-Wellenhof, B. et al., GPS # Theory and Practice, 5th Edition, Springer, 2001
- Teunissen, P.J.G., Kleusberg, A. (Hrsg.), GPS for Geodesy, 2nd Edition, Springer, 1998
- Farell, Jay A., Barth, Matthew, The Global Positioning System & Inertial Navigation
- Misra, P., Enge, P., Global Positioning System # Signals, Measurements and Performance
- Schrödter, Frank, GPS Satelliten-Navigation, Franzis#, 1994

- Bauer, Manfred: Vermessung und Ortung mit Satelliten, 5. neu bearbeitete und erweiterte Auflage, Wichmann, 2003
- Prasad, R., Ruggieri, M., Applied Satellite Navigation # Using GPS, GALILEO, and Augmentation Systems

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Related courses			
Rules for the choice of courses			
Both courses have to be attended.			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture	german
	1,0	Exercise	german

Title	Flight Guidance Systems		
Number	2513220	**Module version**	
Shorttext	MB-IFF-22	**Language**	german
Frequency of offer	only in the summer term	**Teaching unit**	Fakultät für Maschinen-bau
Module duration	1	**Institution**	Institut für Flugführung
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Peter Hecker
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examination	written exam (120 min) or oral exam (30 min)		
Course achievement			

Contents

This module shows the operation of flight control systems and describes systems for typical flight management tasks like haul flight, takeoff and landing. It is shown how to influence the physical measurement principle, the signal processing, display and process each other. The treated in the lecture topics are deepened in exercises with practical examples.

Basic part:
- Methods and principles of flight guidance.
- Required sensors, data processing and filtering (complementary, estimation and observation filter).
- Preparation of the known physical, fluidic and thermodynamic basics.

Application part: Implementation in economically successful equipment and methods within the constraints of the production technology, international standardization and security of the examples
- Air data systems
- Inertial navigation
- Instrument landing systems (ILS, MLS / GLS)

Objective qualification

After successful completion of the module, the students have application-oriented knowledge in the field of flight guidance systems, such as en-route flight, take-off and landing. They are able to recognise the combination of interdisciplinary fundamentals of electrical engineering, physics and engineering science to the specific problems in the design and use of systems for guiding aircraft and to formulate their own proposals for solutions. After completing the module, students will be able to discuss and assess the technologies of current and planned future flight guidance systems. They will be able to discuss and examine the social, political and economic boundary conditions in the introduction of new systems.

Literature

Fundamentals of Kalman Filtering: A Practical Approach; Paul Zarchan, Howard Musoff; Progress in Astronautics and Aeronautics, Vol. 208; American Institute of Aeronautics and Astronautics, Inc.; Virginia 2005

Guidance and Control of Aerospace Vehicles; Cornelius T. Leondes; University of California Engeneering and ASciences Extension Series; McCraw-Hill Book Company, Inc.; New York, San Francisco, Toronto, London; 1963

Strapdown Inertial Navigation Technology; D.H. Titterton, J.L. Weston; The Institution of Electrical Engineers; Stevenage 2004

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Related courses			
Rules for the choice of courses			
Both courses have to be attended.			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture	german
	1,0	Exercise	german

Title	Fundamentals of Flight Guidance		
Number	2513240	**Module version**	
Shorttext	MB-IFF-24	**Language**	german
Frequency of offer	only in the winter term	**Teaching unit**	Fakultät für Maschinenbau
Module duration	1	**Institution**	Institut für Flugführung
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Peter Hecker
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Recommended requirements	No specific requirements are recommended.		
Expected performance/ Type of examination	1 examination element: written exam (120 min)		
Course achievement			

Contents

This module offers an overview over the requirements, principles and technical implementations that are necessary to guide an aircraft through the airspace and to coordinate air traffic (Air Traffic Management, ATM). In order to do so, first the requirements that have to be consider will be introduced, together with necessary direct and deriving aeronautical measures. Along this, an oversight over the systems for aircraft guidance (e.g.) and the structure of airspace will be provided as well.

Objective qualification

Students are able to apply their basic mathematical, physical and mechanical knowledge to the technical implementation of aircraft guidance systems. The students master the mathematical and scientific methods to analyse and abstract the various aeronautical measurement and substitute variables such as e.g. static pressure, dynamic pressure and temperature and to calculate the relevant display variables that can be derived from them such as e.g. barometric altitude, airspeed and rate of descent. The students understand the individual systems for guiding an aircraft. The students acquire a basic knowledge of the organisation of airspace and know the political, economic and ecological boundary conditions in the organisation of European air traffic.

Literature

1. Hesse, F., Hesse, W.; Flugnavigation - Grundlagennavigation, Kartenkunde, Koppelnavigation, Trägheitsnavigation; Breidenbach, 1984; ISBN 3-921715-03-2
2. Guidance and Control of Aerospace Vehicles; Cornelius T. Leondes; University of California Engeneering and Sciences Extension Series; McCraw-Hill Book Company, Inc.; New York, San Francisco, Toronto, London; 1963
3. W. Eichenberger, Flugwetterkunde #- Handbuch für die Fliegerei, Motorbuch Verlag Stuttgart, 1995, 355 Seiten, ISBN 3-613-01683-4
4. Collinson, R.P.G.; Introduction to Avionics Systems; Boston, 2003; ISBN 1-4020-7278-3
5. Handbuch der Luftfahrt; H. Mensen; Springer-Verlag; Berlin; 2003
6. European Air Traffic Management - Principles, Practice and Research; A. Cook; University of Westminster, UK; Ashgate Publishing Limited; Aldershot UK; 2007
7. Mansfeld, W, Satellitenortung und Navigation #- Grundlagen und Anwendung globaler Satellitennavigationssysteme

8. Attention and Situation Awareness # - A NATO AGARD Workshop, Christopher D. Wickens, Univ. of Illinois, Inst. Of Aviation, Aviation Research Laboratory

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Related courses			
Rules for the choice of courses			
Both courses have to be attended.			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture	german
	1,0	Exercise	german

Title	Low-Power Embedded Systems		
Number	2416000000	**Module version**	
Shorttext		**Language**	
Frequency of offer	only in the winter term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	1	**Institution**	Institut für Datentechnik und Kommunikationsnetze
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Andres Gomez
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examination	Written (90 min) or oral exam (30 min)		
Course achievement			

Contents

- An embedded system is some combination of computer hardware and software, either fixed in capability or programmable, that is designed for a specific function or for specific functions within a larger system. For example, they are part of industrial machines, agricultural and process industry devices, automobiles, medical equipment, cameras, household appliances, airplanes, sensor networks, internet-of-things, as well as mobile devices.
- The focus of this lecture is on the design of low-power embedded systems using formal models and utilizing the latest micro-architectural features for improved performance and energy efficiency, with practical examples using C/C++.

Objective qualification

The students
- gain an understanding of specific requirements, issues, and performance evaluations of low-power embedded system applications.
- make design decisions with deep knowledge of the inherent cost-versus-performance trade-offs in low-power, resource-constrained systems.
- apply the principles of real-time operating systems and scheduling theory to design efficient applications with shared resources.
- analyze different architectures, evaluate their hardware-software interface and memory architecture and different optimization techniques for microcontrollers, such as DSP extensions to the instruction set architecture.

Literature

- Edward A. Lee and Sanjit A. Seshia: Introduction to Embedded Systems, A Cyber- Physical Systems Approach, Second Edition, MIT Press, ISBN 978- 0-262-53381-2, 2017.
- P. Marwedel: Embedded System Design, Springer, ISBN 978- 3-030-60909-2, 2021.
- G.C. Buttazzo: Hard Real- Time Computing Systems. Springer Verlag, ISBN 978- 1-4614-0676-1, 2011.
- M. Wolf: Computers as Components – Principles of Embedded System Design. Morgan Kaufman Publishers, ISBN 978-0-128-05387-4, 2016.
- Avelino J. Gonzalez: Computer Programming in C for Beginners, Springer, ISBN 978-3-030-50752-7, 2020.

- Joseph Yiu. The Definitive Guide to ARM® Cortex®-M3 and Cortex®-M4 Processors. Newnes, 2013.

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Low-Power Embedded Systems	2,0	Lecture	english
Literature			
- Edward A. Lee and Sanjit A. Seshia: Introduction to Embedded Systems, A Cyber-Physical Systems Approach, Second Edition, MIT Press, ISBN 978- 0-262-53381-2, 2017. - P. Marwedel: Embedded System Design, Springer, ISBN 978- 3-030-60909-2, 2021. - G. C. Buttazzo: Hard Real-Time Computing Systems. Springer Verlag, ISBN 978- 1-4614-0676-1, 2011. - M. Wolf: Computers as Components – Principles of Embedded System Design. Morgan Kaufman Publishers, ISBN 978-0-128-05387-4, 2016. - Avelino J. Gonzalez: Computer Programming in C for Beginners, Springer, ISBN 978-3-030-50752-7, 2020. - Joseph Yiu. The Definitive Guide to ARM® Cortex®-M3 and Cortex®-M4 Processors. Newnes, 2013.			
Low-Power Embedded Systems	1,0	Exercise	english
Literature			
- Edward A. Lee and Sanjit A. Seshia: Introduction to Embedded Systems, A Cyber-Physical Systems Approach, Second Edition, MIT Press, ISBN 978- 0-262-53381-2, 2017. - P. Marwedel: Embedded System Design, Springer, ISBN 978- 3-030-60909-2, 2021. - G. C. Buttazzo: Hard Real-Time Computing Systems. Springer Verlag, ISBN 978- 1-4614-0676-1, 2011. - M. Wolf: Computers as Components – Principles of Embedded System Design. Morgan Kaufman Publishers, ISBN 978-0-128-05387-4, 2016. - Avelino J. Gonzalez: Computer Programming in C for Beginners, Springer, ISBN 978-3-030-50752-7, 2020. - Joseph Yiu. The Definitive Guide to ARM® Cortex®-M3 and Cortex®-M4 Processors. Newnes, 2013.			

Space & Avionics Systems Electronics - Avionic Systems

Title	Fundamentals of Flight Guidance		
Number	2513240	**Module version**	
Shorttext	MB-IFF-24	**Language**	german
Frequency of offer	only in the winter term	**Teaching unit**	Fakultät für Maschinenbau
Module duration	1	**Institution**	Institut für Flugführung
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Peter Hecker
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Recommended requirements	No specific requirements are recommended.		
Expected performance/ Type of examination	1 examination element: written exam (120 min)		
Course achievement			

Contents

This module offers an overview over the requirements, principles and technical implementations that are necessary to guide an aircraft through the airspace and to coordinate air traffic (Air Traffic Management, ATM). In order to do so, first the requirements that have to be consider will be introduced, together with necessary direct and deriving aeronautical measures. Along this, an oversight over the systems for aircraft guidance (e.g.) and the structure of airspace will be provided as well.

Objective qualification

Students are able to apply their basic mathematical, physical and mechanical knowledge to the technical implementation of aircraft guidance systems. The students master the mathematical and scientific methods to analyse and abstract the various aeronautical measurement and substitute variables such as e.g. static pressure, dynamic pressure and temperature and to calculate the relevant display variables that can be derived from them such as e.g. barometric altitude, airspeed and rate of descent. The students understand the individual systems for guiding an aircraft. The students acquire a basic knowledge of the organisation of airspace and know the political, economic and ecological boundary conditions in the organisation of European air traffic.

Literature

1. Hesse, F., Hesse, W.; Flugnavigation - Grundlagennavigation, Kartenkunde, Koppelnavigation, Trägheitsnavigation; Breidenbach, 1984; ISBN 3-921715-03-2
2. Guidance and Control of Aerospace Vehicles; Cornelius T. Leondes; University of California Engeneering and Sciences Extension Series; McCraw-Hill Book Company, Inc.; New York, San Francisco, Toronto, London; 1963
3. W. Eichenberger, Flugwetterkunde #- Handbuch für die Fliegerei, Motorbuch Verlag Stuttgart, 1995, 355 Seiten, ISBN 3-613-01683-4
4. Collinson, R.P.G.; Introduction to Avionics Systems; Boston, 2003; ISBN 1-4020-7278-3
5. Handbuch der Luftfahrt; H. Mensen; Springer-Verlag; Berlin; 2003

6. European Air Traffic Management - Principles, Practice and Research; A. Cook; University of Westminster, UK; Ashgate Publishing Limited; Aldershot UK; 2007
7. Mansfeld, W, Satellitenortung und Navigation #- Grundlagen und Anwendung globaler Satellitennavigationssysteme
8. Attention and Situation Awareness # - A NATO AGARD Workshop, Christopher D. Wickens, Univ. of Illinois, Inst. Of Aviation, Aviation Research Laboratory

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Related courses			
Rules for the choice of courses			
Both courses have to be attended.			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture	german
	1,0	Exercise	german

Title	Advanced Topics in Network Engineering		
Number	2416780	**Module version**	
Shorttext	ET-IDA-78	**Language**	german
Frequency of offer	only in the winter term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	1	**Institution**	Institut für Datentechnik und Kommunikationsnetze
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Admela Jukan
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examination	oral exam (30 min)		
Course achievement			

Contents

• Cross Layer Design
• All-IP networks
• Integration of IP and Optical
• Inter-domain Routing
• Networks for Data Centers, Storage and Grid Computing
• Economics, Standards and Regulations in Telecommunications
• Applications of Networking in Energy, Automation and Health Care
• Research Literature, Papers and Surveys

Objective qualification

Upon completion of this module, students will have in-depth knowledge of the state of the art and future research topics in the field of architectures and protocols in communication networks. The foundations in this class will help students to better understanding the interaction of complex multi-layered and heterogeneous network architectures and to learning how to engineer the network.

Literature

G. Camarillo, M. García-Martín, The 3G IP Multimedia Subsystem (IMS): Merging the Internet and the Cellular Worlds, John Wiley & Sons, 2004, ISBN: 978-0-470-87156-0
F. Travostino, J. Membretti, G. Karmous-Edwards (Eds.), Grid Networks: Enabling Grids with Advanced Communication Technology, John Wiley & Sons, 2006, ISBN: 978-0-470-01748-7
K. M. Sivalingam and T. Znati (Eds), Wireless Sensor Networks, Kluwer Academic Publishers, 2005, ISBN: 978-1-4020-7883-5

Remark

Knowledge of the content of the module Communication Networks are required.

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	1,0	Exercise	english
Literature			
Include latest research papers, tutorials and industrial standards			
	2,0	Lecture	english
Literature			
Include latest research papers, tutorials and industrial standards			

Title	In-Flight Measuring Techniques		
Number	2513030	**Module version**	
Shorttext	MB-IFF-03	**Language**	german
Frequency of offer	only in the winter term	**Teaching unit**	Fakultät für Maschinen-bau
Module duration	1	**Institution**	Institut für Flugführung
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Peter Hecker
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examination	written exam (120 min) or oral exam (30 min)		
Course achievement			

Contents

Building on the requirements and systems for assisting the pilot in guiding the aircraft covered in the lecture "Fundamentals of Flight Guidance", a broad overview of measurement procedures used in scientific flight measurements is given here. The physical basics of the sensors used (e.g. measurement of pressure, speed, position, attitude) are covered. The processing of the sensor signals to applicable quantities and the influence of sensor errors on the measurement are presented. In addition, simple procedures for combining and coupling sensors (e.g. acceleration measurement and radio direction finding) are dealt with. The mathematical basics necessary for dealing with this problem are included in the lecture and the exercise.

Objective qualification

The students are able to independently discuss interdisciplinary problems of electrical engineering, physics and engineering sciences in the field of flight measurement technology. Using various methodical and analytical approaches, the students are able to assess specific problems in flight measurement technology and implement them in solution approaches. They can explain and reproduce the function of various sensors and the processing of sensor signals.

Literature

Kermode, A.C.; Technik des Fliegens; Heyne Verlag, München, 1977; ISBN 3-453-49069-X

Kracheel, K.; Flugführungssysteme - Blindfluginstrumente, Autopiloten, Flugsteuerungen; Bernard % Graefe Verlag, Bonn, 1993; ISBN 3-7637-6105-5

Gracey, W.; Measurement of Aircraft Speed and Altitude; Wiley verlag, New York, 1981; ISBN 0-471-08511-1

Collinson, R.P.G.; Introduction to Avionics Systems; Boston, 2003; ISBN 1-4020-7278-3

Dokter, F., Steinhauer, J.; Digitale Elektronik in der Messtechnik und Datenverarbeitung; Phillips GmbH, Hamburg, 1975; ISBN 3-87145-273-4

↑

Related courses			
Rules for the choice of courses			
Both courses have to be attended.			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture	german
	1,0	Exercise	german

Title	Avionic systems		
Number	2513120	**Module version**	
Shorttext	MB-IFF-12	**Language**	german
Frequency of offer	only in the winter term	**Teaching unit**	Fakultät für Maschinen-bau
Module duration	1	**Institution**	Institut für Flugführung
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Peter Hecker
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examination	1 Examination element: written exam (120 min) or oral exam (30 min)		
Course achievement			

Contents

In this module, the architecture and functionality of modern avionics systems are considered in order to give students an insight into the increasingly complex avionics structures. For that purpose, various system architectures and bus systems are presented, which are used in current and future generations of aircraft. Furthermore, the processes for the development and approval of avionics systems within the system development process are described. An overview of the necessary standards and regulations is given.

Objective qualification

After completing this module, students possess basic knowledge about the functionality and architecture of current and future avionics systems on aircraft. In addition to the technical aspects, the students gain an insight into the processes necessary for the development and approval of avionics systems taking into account political and economic constraints within the aerospace industry.

Literature

1. Spitzer, C. R. (Editor): Digital Avionics Handbook # Avionics # Development and Implementation. CRC Press, Inc., Boca Raton, Florida, 2007
2. Spitzer, C. R. (Editor): Digital Avionics Handbook # Avionics # Elements, Software and Functions. CRC Press, Inc., Boca Raton, Florida, 2007
3. Newport, J. R.: Avionic Systems Design. CRC Press, Inc., Boca Raton, Florida, 1994

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**

	2,0	Lecture	german
	1,0	Exercise	german

Title	Flight Guidance Systems		
Number	2513220	**Module version**	
Shorttext	MB-IFF-22	**Language**	german
Frequency of offer	only in the summer term	**Teaching unit**	Fakultät für Maschinen-bau
Module duration	1	**Institution**	Institut für Flugführung
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Peter Hecker
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examination	written exam (120 min) or oral exam (30 min)		
Course achievement			

Contents

This module shows the operation of flight control systems and describes systems for typical flight management tasks like haul flight, takeoff and landing. It is shown how to influence the physical measurement principle, the signal processing, display and process each other. The treated in the lecture topics are deepened in exercises with practical examples.

Basic part:
- Methods and principles of flight guidance.
- Required sensors, data processing and filtering (complementary, estimation and observation filter).
- Preparation of the known physical, fluidic and thermodynamic basics.

Application part: Implementation in economically successful equipment and methods within the constraints of the production technology, international standardization and security of the examples
- Air data systems
- Inertial navigation
- Instrument landing systems (ILS, MLS / GLS)

Objective qualification

After successful completion of the module, the students have application-oriented knowledge in the field of flight guidance systems, such as en-route flight, take-off and landing. They are able to recognise the combination of interdisciplinary fundamentals of electrical engineering, physics and engineering science to the specific problems in the design and use of systems for guiding aircraft and to formulate their own proposals for solutions. After completing the module, students will be able to discuss and assess the technologies of current and planned future flight guidance systems. They will be able to discuss and examine the social, political and economic boundary conditions in the introduction of new systems.

Literature

Fundamentals of Kalman Filtering: A Practical Approach; Paul Zarchan, Howard Musoff; Progress in Astronautics and Aeronautics, Vol. 208; American Institute of Aeronautics and Astronautics, Inc.; Virginia 2005

Guidance and Control of Aerospace Vehicles; Cornelius T. Leondes; University of California Engeneering and ASciences Extension Series; McCraw-Hill Book Company, Inc.; New York, San Francisco, Toronto, London; 1963

Strapdown Inertial Navigation Technology; D.H. Titterton, J.L. Weston; The Institution of Electrical Engineers; Stevenage 2004

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Related courses			
Rules for the choice of courses			
Both courses have to be attended.			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture	german
	1,0	Exercise	german

Title	Safety and Certification in Aviation		
Number	2513310	**Module version**	
Shorttext	MB-IFF-31	**Language**	german
Frequency of offer	only in the summer term	**Teaching unit**	Fakultät für Maschinen-bau
Module duration	1	**Institution**	Institut für Flugführung
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Peter Hecker
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Recommended requirements	Basic knowledge of flight guidance		
Expected performance/ Type of examination	1 Examination element: written exam, 90 minutes or oral exam, 30 minutes		
Course achievement			

Contents

This module covers the history of the aircraft certification as well as international certification regulations and procedures. Occurrence reporting and aviation accident investigation are considered as the foundation of the continuing airworthiness of certified aircraft. The tasks and responsibilites of aviation authorities and organisations are described, as well as the approval of Design Organisations and the procedures and privileges thereof. Additionally, the optimization of certification and oversight concepts for enhanced aviation safety are presented. Finally, continuing airworthiness modelling and health monitoring concepts for more effective aviation accident prevention and the future of the air transportation system are given.

Objective qualification

On completion of this module, students will be able to list, reproduce and discuss the procedures involved in aviation regulation and certification. The students are able to discuss the proof of compliance with certification regulations through tests, analyses or simulation. They understand the role of air transport in the field of tension between politics, economy and ecology and can explain their influencing factors.

Literature

http://www.easa.europa.eu/ ?#61472? http://www.icao.int/Pages/default.aspx
http://www.faa.gov/
http://www.jaa.nl/introduction/introduction.html
http://www.lba.de/DE/Home/home_node.html
Cologne Compendium on Air Law in Europe ISBN13: 9783452275233, ISBN: 345227523X, März 2013, Carl Heymanns Verlag KG (Co-Autor)
http://www.bazl.admin.ch/dokumentation/grundlagen/02643/

Remark

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Related courses			
Rules for the choice of courses			
Both courses have to be attended			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	3,0	Lecture/Exercise	german

Title	Flight Control		
Number	2514460	**Module version**	
Shorttext	MB-ILR-46	**Language**	german
Frequency of offer	only in the summer term	**Teaching unit**	Fakultät für Maschinenbau
Module duration	1	**Institution**	Institut für Flugführung
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Peter Hecker
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Recommended requirements	Control engineering and flight mechanics basics		
Expected performance/ Type of examination	written exam (120 min) or oral exam (30 min)		
Course achievement			

Contents

- Principles of automatic control and nonlinear as well as linearized flight dynamics
- Flight control concepts and functional principle of autopilots in civil aviation
- Design of cascaded flight controllers, feedforward control, command prefilter, and state observer
- Servomotors, control modes, and digital controllers
- Full state feedback and optimal control (linear quadratic regulator)

Objective qualification

The students are able to explain and compare flight control concepts, starting from the basics of flight mechanics and control engineering. On the basis of the longitudinal movement of the aircraft via flight characteristics criteria and quality requirements, the students acquire the basics of flight control development. They can work on control engineering problems of an aircraft, such as stability and guidance accuracy, through suitable controller design and adaptation. The students obtain the basic knowledge to apply complex flight control tasks of complete aircraft dynamics.

Literature

Brockhaus R.: Flugregelung. Springer Verlag, Berlin, 1994 (1+2 Auflage).

McRuer, Ashkenas, Graham: Aircraft Dynamics and Automatic Control. Princeton University Press, New Jersey, 1973.

Mensen H.: Moderne Flugsicherung. Springer Verlag, Berlin 1989. Wedrow, Taiz: Flugerprobung. VEB Verlag Technik, Berlin 1959.

Johnson, W: Helicopter Theroy. Princeton University Press, Princeton, 1980.

Schlichting, Truckenbrodt: Aerodynamik des Flugzeuges. Zweiter Band, Springer Verlag, Berlin, 1969.

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Related courses			
Rules for the choice of courses			
Both courses have to be attended.			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture	german
	1,0	Exercise	german

Title	Low-Power Embedded Systems		
Number	2416000000	**Module version**	
Shorttext		**Language**	
Frequency of offer	only in the winter term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	1	**Institution**	Institut für Datentechnik und Kommunikationsnetze
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Andres Gomez
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examination	Written (90 min) or oral exam (30 min)		
Course achievement			

Contents

- An embedded system is some combination of computer hardware and software, either fixed in capability or programmable, that is designed for a specific function or for specific functions within a larger system. For example, they are part of industrial machines, agricultural and process industry devices, automobiles, medical equipment, cameras, household appliances, airplanes, sensor networks, internet-of-things, as well as mobile devices.
- The focus of this lecture is on the design of low-power embedded systems using formal models and utilizing the latest micro-architectural features for improved performance and energy efficiency, with practical examples using C/C++.

Objective qualification

The students
- gain an understanding of specific requirements, issues, and performance evaluations of low-power embedded system applications.
- make design decisions with deep knowledge of the inherent cost-versus-performance trade-offs in low-power, resource-constrained systems.
- apply the principles of real-time operating systems and scheduling theory to design efficient applications with shared resources.
- analyze different architectures, evaluate their hardware-software interface and memory architecture and different optimization techniques for microcontrollers, such as DSP extensions to the instruction set architecture.

Literature

- Edward A. Lee and Sanjit A. Seshia: Introduction to Embedded Systems, A Cyber- Physical Systems Approach, Second Edition, MIT Press, ISBN 978- 0-262-53381-2, 2017.
- P. Marwedel: Embedded System Design, Springer, ISBN 978- 3-030-60909-2, 2021.
- G.C. Buttazzo: Hard Real- Time Computing Systems. Springer Verlag, ISBN 978- 1-4614-0676-1, 2011.
- M. Wolf: Computers as Components – Principles of Embedded System Design. Morgan Kaufman Publishers, ISBN 978-0-128-05387-4, 2016.
- Avelino J. Gonzalez: Computer Programming in C for Beginners, Springer, ISBN 978-3-030-50752-7, 2020.

- Joseph Yiu. The Definitive Guide to ARM® Cortex®-M3 and Cortex®-M4 Processors. Newnes, 2013.

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Low-Power Embedded Systems	2,0	Lecture	english
Literature			
- Edward A. Lee and Sanjit A. Seshia: Introduction to Embedded Systems, A Cyber-Physical Systems Approach, Second Edition, MIT Press, ISBN 978- 0-262-53381-2, 2017. - P. Marwedel: Embedded System Design, Springer, ISBN 978- 3-030-60909-2, 2021. - G. C. Buttazzo: Hard Real-Time Computing Systems. Springer Verlag, ISBN 978- 1-4614-0676-1, 2011. - M. Wolf: Computers as Components – Principles of Embedded System Design. Morgan Kaufman Publishers, ISBN 978-0-128-05387-4, 2016. - Avelino J. Gonzalez: Computer Programming in C for Beginners, Springer, ISBN 978-3-030-50752-7, 2020. - Joseph Yiu. The Definitive Guide to ARM® Cortex®-M3 and Cortex®-M4 Processors. Newnes, 2013.			
Low-Power Embedded Systems	1,0	Exercise	english
Literature			
- Edward A. Lee and Sanjit A. Seshia: Introduction to Embedded Systems, A Cyber-Physical Systems Approach, Second Edition, MIT Press, ISBN 978- 0-262-53381-2, 2017. - P. Marwedel: Embedded System Design, Springer, ISBN 978- 3-030-60909-2, 2021. - G. C. Buttazzo: Hard Real-Time Computing Systems. Springer Verlag, ISBN 978- 1-4614-0676-1, 2011. - M. Wolf: Computers as Components – Principles of Embedded System Design. Morgan Kaufman Publishers, ISBN 978-0-128-05387-4, 2016. - Avelino J. Gonzalez: Computer Programming in C for Beginners, Springer, ISBN 978-3-030-50752-7, 2020. - Joseph Yiu. The Definitive Guide to ARM® Cortex®-M3 and Cortex®-M4 Processors. Newnes, 2013.			

Automotive Systems Engineering

Title	Data Bus Systems		
Number	2412400	**Module version**	
Shorttext	ET-IFR-40	**Language**	german
Frequency of offer	only in the winter term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	1	**Institution**	
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Markus Maurer
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examination	oral exam (30 minutes) or written exam (60 minutes), depending on the number of participants		
Course achievement			

Contents

- Bus architectures and access methods
- Physical layers
- Network and transport layer according to ISO layer model using the example of the OSEK standard for Network communication and management
- LIN, CAN, TTP, FlexRay, MOST and Bluetooth
- Interbus, Profibus, HART, ASI
- Procedure for the selection of a suitable data bus system for a selected application

Objective qualification

After completing this module, students have basic knowledge of architectures and protocol standards of data bus systems in modern motor vehicles as well as industrial plants. They are familiar with functional principles and properties of commonly used data buses from various application areas. The fundamentals learned enable them to independently design or analyze and evaluate networked systems.

Literature

- Zimmermann, Schmidgall, Bussysteme in der Fahrzeugtechnik, Vieweg Verlag 2006, ISBN 3-8348-0166-6
- G. Schnell, B. Wiedemann, Bussysteme in der Automatisierungs- und Prozesstechnik, Vieweg Verlag 2006, ISBN 3-8348-0045-7

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Related courses			
Rules for the choice of courses			
both lectures and exercises must be attended			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture	german
Literature			
- Folienssammlung - Literaturempfehlungen in der Vorlesung - Etschberger, Controller-Area-Network, Hanser Verlag - Grzemba: LIN-Bus, Franzis Verlag - Rausch: Flexray, Hanser Verlag - Schäuffele: Automotive Software Engineering, Vieweg Verlag - Zimmermann: Bussysteme in der Fahrzeugtechnik, Vieweg Verlag - Schnell, Wiedemann: Bussysteme in der Automatisierungs- und Prozesstechnik			
	1,0	Exercise	german

Title	Automotive Systems Engineering		
Number	2412660	**Module version**	
Shorttext	ET-IFR-66	**Language**	german
Frequency of offer	only in the winter term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Markus Maurer
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination	written exam (60 minutes) or oral exam (30 minutes)		
Course achievement			

Contents

- architectures in vehicle development
- development processes for complex automotive systems
- simulation, test and development methods for complex automotive systems
- safety requirements and concepts
- software components and architectures
- formal description methods
- examples from driver assistance and electric mobility

Objective qualification

Handling complexity in the development and production process is one of the core competencies of today's car manufacturers. After completing this module, students will have an overview of established and innovative methods for handling complexity in vehicle development. They learn about architectures, methods for requirements management, processes, description methods as well as test, simulation and development tools for vehicle development.
After completing this module, students will be able to analyze and enhance existing processes, and development and test methods in companies. Students become capable to design innovative automotive systems.
Special attention will be payed to the safety of the systems during the design activities. For given tasks, they learn to derive requirements for the systems systematically.

Literature

- J. Schäuffele, T. Zurawka: Automotive Software Engineering, Vieweg Verlag, ISBN: 978-3834800510
- Maurer, Markus, et al. Autonomous driving: technical, legal and social aspects. Springer Nature, 2016.
- Schräder, Tobias, et al. "Compensating for the Absence of a Required Accompanying Person: A Draft of a Functional System Architecture for an Automated Vehicle." 2021 IEEE International Intelligent Transportation Systems Conference (ITSC). IEEE, 2021.
- Nolte, Marcus, et al. "Supporting Safe Decision Making Through Holistic System-Level Representations & Monitoring--A Summary and Taxonomy of Self-Representation Concepts for Automated Vehicles." arXiv preprint arXiv:2007.13807 (2020).
- Jatzkowski, Inga, et al. "A Knowledge-based Approach for the Automatic Construction of Skill Graphs for Online Monitoring." 2021 IEEE Intelligent Vehicles Symposium (IV). IEEE, 2021.

- Graubohm, Robert, et al. "Towards efficient hazard identification in the concept phase of driverless vehicle development." 2020 IEEE Intelligent Vehicles Symposium (IV). IEEE, 2020.
- Stolte, Torben, et al. "Towards Safety Concepts for Automated Vehicles by the Example of the Project UNICARagil." 29th Aachen Colloquium Sustainable Mobility 2020, 5.–7. Oktober 2020. 2020.
- Menzel, Till, et al. "From functional to logical scenarios: Detailing a keyword-based scenario description for execution in a simulation environment." 2019 IEEE Intelligent Vehicles Symposium (IV). IEEE, 2019.
- Nolte, Marcus, et al. "Representing the Unknown–Impact of Uncertainty on the Interaction between Decision Making and Trajectory Generation." 2018 21st International Conference on Intelligent Transportation Systems (ITSC). IEEE, 2018.
- Bagschik, Gerrit, et al. "A system's perspective towards an architecture framework for safe automated vehicles." 2018 21st International Conference on Intelligent Transportation Systems (ITSC). IEEE, 2018.
- Menzel, Till, Gerrit Bagschik, and Markus Maurer. "Scenarios for development, test and validation of automated vehicles." 2018 IEEE Intelligent Vehicles Symposium (IV). IEEE, 2018.
- Matthaei, Richard, and Markus Maurer. "Functional system architecture for an autonomous on-road motor vehicle." Automotive Systems Engineering II. Springer, Cham, 2018. 93-120.
- Stolte, Torben, et al. "Hazard analysis and risk assessment for an automated unmanned protective vehicle." 2017 IEEE Intelligent Vehicles Symposium (IV). IEEE, 2017.
- Ulbrich, Simon, et al. "Defining and substantiating the terms scene, situation, and scenario for automated driving." 2015 IEEE 18th international conference on intelligent transportation systems. IEEE, 2015.

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture	german
Literature			
Markus Maurer (Hrsg), Hermann Winner (Hrsg): Automotive Systems Engineering, Springer Verlag, 2013 J. Schäuffele, T. Zurawka: Automotive Software Engineering, Vieweg Verlag, ISBN: 978-3834800510			
	2,0	Exercise	german
Literature			
Markus Maurer (Hrsg), Hermann Winner (Hrsg): Automotive Systems Engineering, Springer Verlag, 2013 J. Schäuffele, T. Zurawka: Automotive Software Engineering, Vieweg Verlag, ISBN: 978-3834800510			

Title	Pattern Recognition		
Number	2424690	**Module version**	
Shorttext	ET-NT-69	**Language**	english german
Frequency of offer	every term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Tim Fingscheidt
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination	Oral exam 30 min. or written exam 90 min.		
Course achievement			

Contents

- Bayesian decision rule
- Quality metrics in pattern recognition
- Supervised learning with parametric distributions
- Supervised learning with non-parametric distributions, classification
- Linear discriminant functions, single-layer perceptron
- Support vector machines (SVMs)
- Multi-layer perceptron, neural networks (NNs)
- Deep learning
- Unsupervised learning, clustering methods

Note: For pattern recognition using hidden Markov models (HMMs), a separate more in-depth module, Spoken Language Processing (ET-NT-68), is offered in the summer semester.

Objective qualification

Upon completion of this module, students gain fundamental knowledge about methods and algorithms for classification of data. They are capable to select the appropriate means for real-world problems, to design a solution and to evaluate it.

Literature

- R.O. Duda, P.E. Hart, D.G. Stork: Pattern Classification, Wiley, 2001
- C.M. Bishop: Pattern Recognition and Machine Learning, Springer, 2006

Remark

Basic knowledge of statistics, such as acquired in the module "Probability Theory and Statistics", facilitates the understanding of the lecture.

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture	english german
Literature			
- R. O. Duda, P. E. Hart, D. G. Stork: Pattern Classification, Wiley, 2001 - C. M. Bishop: Pattern Recognition and Machine Learning, Springer, 2006			
	2,0	Seminar	english german
Literature			
- Vorlesungsfolien - R. O. Duda, P. E. Hart, D. G. Stork: Pattern Classification, Wiley, 2001 - C. M. Bishop: Pattern Recognition and Machine Learning, Springer, 2006			

Title	Vehicle Electronics		
Number	2412480	**Module version**	
Shorttext	ET-IFR-48	**Language**	german
Frequency of offer	only in the winter term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	1	**Institution**	
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Markus Maurer
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examination	Written exam (90 min) or oral exam (30 min)		
Course achievement			

Contents

- Product development process of vehicles
- Automotive electrics and electronics including requirements and standards
- Hardware architecture of electronic vehicle systems
- Electrical energy in the vehicle
- Wiring system, design criteria, wiring system architecture and development process
- Electronic systems in the powertrain
- Alternative energy sources and drive concepts
- Chassis control

Objective qualification

Upon completion of this module, students will have an overview of the complexity of the vehicle development process and about environment, requirements and boundary conditions for electronic systems in motor vehicles. In particular, they have acquired an understanding of the architectures of ECUs and sensors and basic sensor principles using the example of selected system functions in the field of drivetrain and chassis development.

Literature

- Folien zur Vorlesung - Bosch: Autoelektrik Autoelektronik, Vieweg Verlag
- M. Krüger: Grundlagen der Kraftfahrzeugelektronik, Hanser Verlag
- J. Schäuffele, T. Zurawka: Automotive Software Engineering, Vieweg Verlag
- Bosch: Sicherheits- und Komfortsysteme, Vieweg Verlag

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Related courses			
Rules for the choice of courses			
German			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	1,0	Exercise	german
	2,0	Lecture	german

Literature

- Folien zur Vorlesung
- Bosch: Autoelektrik Autoelektronik, Vieweg Verlag
- M. Krüger: Grundlagen der Kraftfahrzeugelektronik, Hanser Verlag
- J. Schäuffele, T. Zurawka: Automotive Software Engineering, Vieweg Verlag

Title	Postgraduate seminar Vehicle Electronics		
Number	2412510	**Module version**	
Shorttext	ET-IFR-51	**Language**	german
Frequency of offer	every term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	1	**Institution**	Institut für Regelungstechnik
Hours per Week / ECTS	2 / 5,0	**Module owner**	Prof. Dr. Markus Maurer
Workload (h)	150		
Class attendance (h)	28	**Self studying (h)**	122
Compulsory requirements			
Expected performance/ Type of examination	Written elaboration or oral exam		
Course achievement			

Contents
Changing current research topics from the field of electronic vehicle systems
Objective qualification
After completion of this module, the students will have advanced skills in writing scientific papers. Within the scope of the advanced seminar, changing current research topics from the field of electronic vehicle systems will be elaborated, deepened and scientifically processed.
Literature
Remark
The module can only be taken once. Participants will be admitted to the course by the person responsible for the module in order to ensure that the qualification objectives of the module can be achieved.

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Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture	german

	0,0	Project	german

Title	Mathematical Methods for Electronic Vehicle Systems		
Number	2412560	**Module version**	
Shorttext	ET-IFR-56	**Language**	german
Frequency of offer	only in the winter term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	1	**Institution**	Institut für Regelungstechnik
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Markus Maurer
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination	Written exam (60 min) or oral exam (30 min)		
Course achievement			

Contents

Dynamic state estimation:
Probability theory and distribution functions, system descriptions, filtering and smoothing, Kalman and particle filters

Nonlinear optimization methods:
Necessary and sufficient optimality conditions, one-dimensional minimization, minimization without constraints, minimization with constraints

Objective qualification

After completing this module, students will have basic knowledge of numerical optimization methods and associated standard software libraries. They are also familiar with methods and the current state of the art for object tracking in the field of machine perception of automated vehicles. Students will be able to independently solve optimization problems for electronic vehicle systems and implement algorithms for object tracking with radar or lidar sensors.

Literature

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Related courses

Rules for the choice of courses

Compulsory attendance

Name of the course	**SWS**	**Eventtype**	**Language**

Mathematical Methods for Electronic Vehicle Systems	2,0	Lecture	german
Mathematical Methods for Electronic Vehicle Systems	2,0	Exercise	german

Title	Advanced Topics in Automotive Systems Engineering		
Number	2412590	**Module version**	
Shorttext	ET-IFR-35	**Language**	english
Frequency of offer	only in the winter term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	1	**Institution**	Institut für Regelungstechnik
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Markus Maurer
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examination	Presentation (§ 9 (7) APO)		
Course achievement			

Contents

Automotive industry is changing rapidly these days. Both electric drives and autonomous driving change the requirements on vehicles dramatically. These changes include innovative vehicle systems, vehicle concepts and many aspects of systems engineering. In this class, selected topics will be presented and discussed by both scientists and students. These topics include electric vehicles, autonomous driving, safety and security aspects, system architecture, development processes and other related fields.

Objective qualification

The students will study selected scientific topics in automotive systems engineering on an advanced level. They will be trained to present a scientific topic of their choice to a scientific audience. Adjacent to their presentation they have to defend their major theses in an extended discussion.

Literature

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Related courses

Rules for the choice of courses

Compulsory attendance

Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Seminar	english

	1,0	Training	english

Title	Automated Road Vehicles: From Assistance to Autonomy		
Number	2412620	**Module version**	
Shorttext	ET-IFR-62	**Language**	german
Frequency of offer	only in the summer term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Markus Maurer
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination	Written exam (60 min) or oral exam (30 min)		
Course achievement			

Contents

-probabilistic knowledge representation for driver assistance and vehicle guidance systems
- radar-based and visual machine perception
- machine situation detection and behavioural decision-making
- human-machine-interaction
- design and test of driver assistance and vehicle guidance systems

Objective qualification

After completing this module, students will have basic knowledge of driver assistance systems and automated vehicles. They are familiar with the current state of the art in driver assistance systems and automated driving functions and know about the function-determining factors. The students are able to independently plan customer-value driver assistance systems and systems for vehicle automation.

Literature

- Handbook of Driver Assistance Systems;
Basic Information, Components and Systems for Active Safety and Comfort; Editors: Winner, H., Hakuli, S., Lotz, F.,
Singer, C. (eds.); 1. Edition 2016 Springer;
available free of charge for students via Springer-Link

Remark

The course “Automotive Systems Engineering” provides helpful background knowledge for this course; however, it is not a mandatory prerequisite for participation.

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Related courses			
Rules for the choice of courses			
Only one of the three modules ET-IFR-42, ET-IFR-58, ET-IFR-62 can be chosen.			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture	german
Literature			
- Hermann Winner (Hrsg.), Stephan Hakuli (Hrsg.), Gabriele Wolf (Hrsg.): Handbuch Fahrerassistenzsysteme Grundlagen, Komponenten und Systeme für aktive Sicherheit und Komfort, Springer, 3. Auflage 2015, ISBN: 978-3658057336 - R. Bishop. Intelligent Vehicle Technology and Trends, Artech House, Boston, 2005, ISBN: 978-1580539111 - M. Maurer, C. Stiller. Fahrerassistenzsysteme mit maschineller Wahrnehmung, Springer, Heidelberg, 2005, ISBN: 978-3540232964 - S. Thrun, W. Burgard, D. Fox. Probabilistic Robotics			
	2,0	Exercise	german
Literature			
- Hermann Winner (Hrsg.), Stephan Hakuli (Hrsg.), Gabriele Wolf (Hrsg.): Handbuch Fahrerassistenzsysteme Grundlagen, Komponenten und Systeme für aktive Sicherheit und Komfort, Springer, 3. Auflage 2015, ISBN: 978-3658057336 - R. Bishop. Intelligent Vehicle Technology and Trends, Artech House, Boston, 2005, ISBN: 978-1580539111 - M. Maurer, C. Stiller. Fahrerassistenzsysteme mit maschineller Wahrnehmung, Springer, Heidelberg, 2005, ISBN: 978-3540232964 - S. Thrun, W. Burgard, D. Fox. Probabilistic Robotics			

Title	High-Voltage Safety in the Motor Vehicle		
Number	2412650	**Module version**	
Shorttext	ET-IFR-65	**Language**	german
Frequency of offer	only in the winter term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	1	**Institution**	
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Markus Maurer
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examination	oral exam (30 minutes) or written exam (60 minutes)		
Course achievement	Lab course		

Contents

The contents result primarily from the qualification measures QM2b+3a of the German Legal Accident Insurance (DGUV) Information 200-005 for work on vehicles with high-voltage systems.
Electrotechnical work in a voltage-free state on non-HV intrinsically safe systems level 2 according to DGUV Information 200-005" and working under voltage and near touchable live parts Level 3 according to DGUV Information 200-005".

Objective qualification

After completing this module, the students have basic knowledge on HV safety resulting from the qualification measures QM2b+3a of DGUV Information 200-005 for work on vehicles with high-voltage systems. They achieved in particular, an understanding of the electrical hazards associated with the use of HV systems in vehicles. The students will understand and be able to apply appropriate processes guaranteeing safety and health in electrotechnical work under high voltage.
The qualification is documented with the successful participation in the practical exercises as well as a proof of the acquired skills and knowledge by an examination.

Literature

- Folien zum Seminarinhalt
- Arbeitsblätter
- Gesetzliche Unterlagen wie:
- DGUV Information 200-005 (bisherige Bezeichnung: BGI/GUV-I 8686)
- ECE R 100
- DGUV Regel 103-011 (bisherige Bezeichnung: BGR A3)

Remark

Compulsory attendance at the seminar:
Participation in the seminar is required and recorded by attendance list and signature. It will be carried out short tests on the individual contents in the event.

The attendance as well as the tests in the seminar are mandatory so that the lecturer is able to assess the individual level of knowledge and training of the participants as well as their personal suitability before the students will perform experiments of their own.
Limitation of the number of participants:
The number of participants is limited to 20 people so that the required practical part is sufficiently can be mediated.
Additional note:
The practical exercises take place at the institute's training stands. Training contents include measurements of the output voltages on a frequency converter and the replacement of battery cells. These works will be performed under high voltage. If they are not carried out in accordance with the regulations and with the necessary knowledge, they are life threatening. It is therefore important to reduce the risk for students. The lecturer must therefore obtain an overview of the level of knowledge and training of the participants as well as their personal suitability in advance. This goal is achieved through compulsory attendance and tests in the seminar.

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Seminar	german
Literature			
Folien zum Seminarinhalt Arbeitsblätter Gesetzliche Unterlagen wie: DGUV Information 200-005 (bisherige Bezeichnung: BGI/GUV-I 8686) ECE R 100 DGUV Regel 103-011 (bisherige Bezeichnung: BGR A3)			
	1,0	Internship	german
Literature			
Folien zum Seminarinhalt Arbeitsblätter Gesetzliche Unterlagen wie: DGUV Information 200-005 (bisherige Bezeichnung: BGI/GUV-I 8686) ECE R 100 DGUV Regel 103-011 (bisherige Bezeichnung: BGR A3)			

Title	Electrical Machines and Drives		
Number	2414180	**Module version**	
Shorttext	ET-IMAB-18	**Language**	german
Frequency of offer	only in the winter term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Markus Henke
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination	Written exam (120 minutes) or oral exam (30 minutes)		
Course achievement			

Contents

- Speed and torque control of direct current and three-phase drives with power electronic control circuits
- Operating behaviour of permanent magnet and salient pole synchronous machines
- Modelling of electrical machines and drives
- Design and control of magnetic bearings

Objective qualification

After completing the Electrical Drives module, students will have an overview of the functions of the most important DC and mmost important direct current and rotating field machines. The in-depth fundamentals enable the assessment of existing motor and generator drives as well as the design of simple drive systems for industry and mobile applications.

Literature

Binder, Elektrische Maschinen und Antriebe: Grundlagen, Betriebsverhalten, Springer
Schröder D., Elektrische Antriebe Grundlagen, Springer
Hofmann W., Elektrische Maschinen, Pearson
Hagl, Elektrische Antriebstechnik, Hanser

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Related courses

Rules for the choice of courses

Compulsory attendance

Name of the course	**SWS**	**Eventtype**	**Language**

	2,0	Exercise	german
Literature			
Skript			

	2,0	Lecture	german
Literature			
Skript, H.O. Seinsch, Ausgleichsvorgänge bei elektrischen Antrieben, Teubner Verlag, Stuttgart			

Title	Drives for Electric Road Vehicles		
Number	2414220	**Module version**	
Shorttext	ET-IMAB-22	**Language**	german
Frequency of offer	only in the winter term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Markus Henke
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination	Written exam (120 min) or oral exam (30 min)		
Course achievement			

Contents

The module teaches a system-oriented approach to the design of electric drives in road vehicles by considering the vehicle as a mechatronic system. Starting from the basics of drive design (driving resistances, power transmission), common drive topologies of road vehicles are dealt with. Special features of the motors used with regard to their function and their properties as inverter-fed drives are dealt with. The knowledge gained here on the design and dimensioning of traction drives is then applied to road vehicles (electric and hybrid vehicles).

Objective qualification

After completing the module, the students know the essential structures of conventional and new types of vehicle drives and the electrical machines and converters used in these vehicles. They are also able to carry out a simple design.

Literature

Babiel, Elektrische Antriebe in der Fahrzeugtechnik, Vieweg
Reif, Noreikat, Bergeest, Kraftfahrzeug-Hybridantriebe, Springer

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Related courses

Rules for the choice of courses

Compulsory attendance

Name of the course	**SWS**	**Eventtype**	**Language**
	1,0	Lecture	german

	1,0	Lecture	german
	2,0	Exercise	german

Title	Advanced Seminar "Machine Learning"		
Number	2424600	**Module version**	
Shorttext	ET-NT-57	**Language**	german
Frequency of offer	only in the summer term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	1	**Institution**	
Hours per Week / ECTS	2 / 5,0	**Module owner**	Prof. Dr. Tim Fingscheidt
Workload (h)	150		
Class attendance (h)	28	**Self studying (h)**	122
Compulsory requirements			
Expected performance/ Type of examination	Written paper		
Course achievement			

Contents

Changing current research topics in the field of machine learning.

Objective qualification

After completing the module, students will possess advanced skills in writing a scientific paper. In the course of the advanced seminar, current research topics from the area of machine learning are discussed, deepened, and scientifically prepared. The participants will read scientific publications, present them and discuss them jointly. The structure of a scientific conference publication will be covered as well as strategies for the writing of the standard sections of a paper.
This course has a discursive character, therefore regular attendance of the participants is required.

Literature

Literature will be handed out in the seminar

Remark

Basic knowledge of the topics "pattern recognition"/"machine learning" is expected, especially in the field of neural networks and support vector machines.

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Related courses

Rules for the choice of courses

Compulsory attendance

Name of the course	SWS	Eventtype	Language

	2,0	Lecture	german
Literature			
Literatur wird im Seminar ausgegeben.			

	0,0	Project	german
Literature			
Literatur wird im Seminar ausgegeben.			

Title	Electromagnetic Compatibility in Automotive Systems		
Number	2497050	**Module version**	
Shorttext	ET-IFR-50	**Language**	german
Frequency of offer	only in the summer term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Thomas Form
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination	oral exam or written exam (90 min)		
Course achievement			

Contents

- Electromagnetic environment and protection goals in the automotive sector;
- Sources of interference and coupling mechanisms;
- EMC-compliant power supply, vehicle electrical system architecture and power types;
- Measures to ensure EMC: grounding, shielding and filtering;
- EMC development process and test methods for vehicles and components, for conducted and radiated interference and ESD;
- EMC standards in the automotive sector and statutory EMC requirements;
- Product responsibility and liability

Objective qualification

After completing this module, students will have basic knowledge of typical sources and sinks of electromagnetic interference in motor vehicles and will be familiar with the principles of coupling mechanisms of interference in the electrical system of a motor vehicle. The basics they have learned enable them to independently select basic EMC protection measures, analyse and evaluate their effectiveness and select and apply common procedures for testing EMC.

Literature

- M.I. Montrose; EMC and the printed Circuit Board - Design, Theory, and Layout made simple, IEEE-Press, ISBN: 978-0780347038
- V.P. Kodali; Engineering Electromagnetic Compatibility - Principles, Meassurements, and Technologies, IEEE-Press, ISBN: 978-0780347434

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture	german
Literature			
• M. I. Montrose, EMC and the printed Circuit Board - Design, Theory, and Layout made simple, IEEE-Press • V. P. Kodali; Engineering Electromagnetic Compatibility - Principles, Measurements, and Technologies, IEEE-Press			
	1,0	Exercise	german
Literature			
• M. I. Montrose, EMC and the printed Circuit Board - Design, Theory, and Layout made simple, IEEE-Press • V. P. Kodali; Engineering Electromagnetic Compatibility - Principles, Measurements, and Technologies, IEEE-Press			
	1,0	Excursion	german
Literature			
• M.I. Montrose, EMC and the printed Circuit Board - Design, Theory, and Layout made simple, IEEE-Press, ISBN: 978-0780347038 • V.P. Kodali; Engineering Electromagnetic Compatibility - Principles, Measurements, and Technologies, IEEE-Press, ISBN: 978-0780347434			

Title	Car Body Development		
Number	2516190	**Module version**	
Shorttext	MB-IK-19	**Language**	german
Frequency of offer	only in the summer term	**Teaching unit**	Fakultät für Maschinen-bau
Module duration	1	**Institution**	Institut für Konstrukti-onstechnik
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Thomas Vietor
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examina-tion	Written exam (120 min) or oral exam (30 min)		
Course achievement			

Contents

- Requirements towards the vehicle and bodywork development
- Vehicle conception and package
- The principle structural construction of a bodywork (components)
- Bodywork construction (shell- , frame-, monocoque- and composite design)
- Fundamental influences on the body layout
- Crash and (heavy) force path and their influence on the bodywork design and the #structure
- Manufacturing technologies of the bodywork
- Materials in the bodywork construction
- Possible applications for fiber composite-components

Objective qualification

The students are capable of:

- Defining, develop and assess a vehicle body concept per the predetermined requirements
- Differentiating the different body designs based on the characteristics and determine their usage
- Naming and explaining the basic structural body and the interaction of the individual components of the bodywork
- Illustrating the force paths in a bodywork based on a given bodywork structure, to justify and asses the relevant component dimensioning
- Deducing and assessing the usage from manufacturing technologies and materials based on the given requirements towards a vehicle and its production

Literature

Anselm, Dieter; Die PKW-Karosserie : Konstruktion, Deformationsverhalten, Unfallinstandsetzung; ISBN: 3802317068; Würzburg : Vogel, 1997

Braess, Hans-Hermann (Seiffert, Ulrich.; Braess-Seiffert, ...;); Vieweg Handbuch Kraftfahrzeugtechnik ISBN: 3834802220; Wiesbaden : Vieweg, 2007

Koschorrek, Ralph; Systematisches Konzipieren mittels Ähnlichkeitsmethoden am Beispiel von PKW-Karosserien ISBN: 978-3-8325-1784-7; Berlin : Logos-Verl, 2007

Pippert, Horst; Karosserietechnik : Personenkraftwagen, Lastkraftwagen, Omnibusse ; Leichtbau, Werkstoffe, Fertigungstechniken ; Konstruktion und Berechnung ISBN: 3802317254; Würzburg : Vogel, 1998

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Related courses			
Rules for the choice of courses			
Lecture and excercise have to be attended.			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	3,0	Lecture/Exercise	german

Title	Drive Technologies		
Number	2517140	**Module version**	
Shorttext	MB-ILF-14	**Language**	german
Frequency of offer	only in the winter term	**Teaching unit**	Fakultät für Maschinenbau
Module duration	1	**Institution**	Institut für mobile Maschinen und Nutzfahrzeuge
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Ludger Frerichs
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examination	1 examination element: written exam (90 min) or oral exam (30 min)		
Course achievement			

Contents

- Energy storage and transport #
- primary energy converters #
- clutches #
- transmission systems with one power path #
- power split transmissions #
- end drives for traction and process drives #
- system considerations of complex powertrain structures

Objective qualification

After successful completion of this module, students are able to: # explain the tasks of the components along the energy flow in the powertrain of a mobile machine (process and traction drives) and a vehicle. # explain the origin or production of energy sources suitable for mobility in principle and to evaluate them for application. # understand the functions of mechanical transmissions by means of transmission schemes and to determine the power flows for given operating conditions. # calculate and design mechanical and hydraulic transmissions under consideration of given boundary conditions (e.g. performance requirements, transmission design). # evaluate transmission designs and select a suitable design for a specific application. # categorize power split transmissions with regard to their design and to predict and calculate power flow states for different operating conditions. # compare and evaluate holistic drive systems with regard to conceptual design and efficiency.

Literature

- Looman, J.: Zahnradgetriebe: Grundlagen, Konstruktionen, Anwendungen in Fahrzeugen. Berlin Heidelberg: Springer-Verlag 2009, ISBN 9783540894605.
- Matthies, H. J.; Renius, K. T.: Einführung in die Ölhydraulik. Wiesbaden: Springer Vieweg 2014, ISBN 978-3-658-06715-1.
- Pischinger, S.; Seiffert, U. (Hrsg.): Vieweg Handbuch Kraftfahrzeugtechnik. Wiesbaden: Springer Vieweg 2016, ISBN 9783658095277.
- Renius, K. T.: Fundamentals of Tractor Design. Cham: Springer Verlag 2020, ISBN 9783030328047.
- Tschöke, H.: Die Elektrifizierung des Antriebsstrangs: Basiswissen, Wiesbaden: Springer Vieweg 2015, ISBN 9783658046439.

- Will, D.; Gebhardt, N. (Hrsg.): Hydraulik: Grundlagen, Komponenten, Systeme, Berlin [u.a.]: Springer Vieweg 2014, ISBN 9783662444016.

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture	german
	1,0	Exercise	german

Title	Automotive Drive Systems		
Number	2534050	**Module version**	
Shorttext	MB-FZT-05	**Language**	german
Frequency of offer	only in the winter term	**Teaching unit**	Fakultät für Maschinen-bau
Module duration	1	**Institution**	Institut für Fahrzeug-technik
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Roman Henze
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examina-tion	written exam (90 min)		
Course achievement			

Contents

- Development goals in the automotive industry
- Overview on drivetrain components
- Launch devices: clutches and hydrodynamic converter
- Functionality of all transmission concepts
- All wheel drive systems
- Sources and impact of acoustic phenomena in the drive train, vibration damping
- Latest construction examples

Objective qualification

After completion of the module students are able to work with fundamental issues in the chassis and brake construction. Thus, participants will have an understanding and knowledge of the functioning of all major construction in the chassis and braking systems. In addition, students will be able to give an overview of the most important methods of construction, reproduce their advantages and disadvantages as well as the characteristic fields of application of the different brake and chassis structures. Furthermore, the students are able to do calculations of components, such as spring, damper, brake systems, etc.

Literature

PISCHINGER, S; SEIFFERT, U. (HRSG.): Handbuch Kraftfahrzeugtechnik, Vieweg Verlag, 2016, ISBN 978-3-8348-8298-1
ROBERT BOSCH GMBH: Kraftfahrzeugtechnisches Handbuch, 29. Auflage, Vieweg & Sohn, 2018, ISBN 3658235837
HAKEN, K.-L.: Grundlagen der Kraftfahrzeugtechnik, 5. Auflage,ISBN 3446454128, Carl Hanser Verlag, 2018
FISCHER, R.; KÜ#ÜKAY, F.; JÜRGENS, G.; NAJORK, R.; POLLAK, B.: Das Getriebebuch, 2. Auflage, Berlin: Springer Verlag, 2016

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Related courses			
Rules for the choice of courses			
Both courses have to be attended.			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture	german
	1,0	Exercise	german

Title	Alternative, electro and hybrid drives		
Number	2534060	**Module version**	
Shorttext	MB-FZT-06	**Language**	german
Frequency of offer	only in the winter term	**Teaching unit**	Fakultät für Maschinenbau
Module duration	1	**Institution**	Institut für Fahrzeugtechnik
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Roman Henze
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examination	1 Examination element: written exam (90 min)		
Course achievement			

Contents

- Historical overview of alternative powertrains
- Legal and political frameworks for powertrain development
- Primary energy sources and fuels
- Hybrid and electric drivetrains
- Components of hybrid and electric drivetrains
- Fuel cell electric vehicles
- Comparison of drivetrain concepts
- Outlook towards future powertrain development trends

Objective qualification

After completion of the module, students are able to evaluate alternative drive concepts as well as their design and conception. Students are able to discuss the historical, legal, economic and ecological boundary conditions for alternative, electric and hybrid drives on the basis of a comprehensive foundation. The students are able to assess different measures for improving efficiency and thus reducing fuel consumption on the basis of the elements of energy consumption as well as their knowledge about the influences of powertrain and vehicle parameters. The students can enumerate exemplary field conditions for the use of alternative and electrified vehicles and derive the resulting requirements for the powertrain. The students are independently able to classify electric and hybrid vehicles and their components with regard to their structure and functions, to integrate them into new vehicle concepts and to compare them on the basis of efficiency, performance, cost and installation space criteria. In addition, the students will be able to describe the transmissions integrated in HEV and BEV, their specifics and requirements as well as the requirements for chassis and brakes in vehicles with electrified drives using examples. Furthermore, the students are able to classify and evaluate electric motors, power electronics, energy sources and storage systems based on appropriate criteria.

Literature

- TSCHÖKE, H.: Die Elektrifizierung des Antriebsstrangs -Grundlagen -vom Mikro-Hybrid zum vollelektrischen Antrieb, Springer Verlag, 2019
- NAUNHEIMER, H.: Fahrzeuggetriebe #Grundlagen, Auswahl, Auslegung und Konstruktion, Springer Verlag, 2019
- HOFMANN, P.: Hybridfahrzeuge, Springer Verlag, 2014
- KAMPKER, A.: Elektromobilität, Springer Verlag, 2018

- KREMSER, A.: Elektrische Maschinen und Antriebe #Grundlagen, Motoren und Anwendungen, Springer Verlag, 2017
- KLELL, M.: Wasserstoff in der Fahrzeugtechnik #Erzeugung, Speicherung, Anwendung, Springer Verlag, 2018
- REIF, K.: Basiswissen Hybridantriebe und alternative Kraftstoffe, Springer Verlag, 2018
- AVL: Engine and Environment, Proceedings, AVL, 2018
- ZACH, F.: Leistungselektronik, Springer Verlag Wien, 2010
- GEHRINGER, B.: 39. Internationales Wiener Motorensymposium, Proceedings, VDI Fortschritt-Berichte, 2018
- BINDER, A.: Elektrische Maschinen und Antriebe #Grundlagen, Betriebsverhalten, Springer Verlag, 2017
- NELSON, V.: IntroductiontoRenewableEnergy, CRC Press, 2015
- DENTON, T.: ElectricandHybrid Vehicles, CRC Press, 2016
- STAN, C.: Alternative Antriebe für Automobile: Hybridsysteme, Brennstoffzellen, alternative Energieträger, Springer Verlag, 2012
- VOGEL, M.: Kompendium Li-Ionen Batterien. Grundlagen, Bewertungskriterien, Gesetze und Normen, VDE Verband der Elektrotechnik, 2015
- LIEBL, J.: Energiemanagement im Kraftfahrzeug, Springer Verlag, 2014 ITS
- NIDERSACHSEN: Hybrid and ElectricVehicles, Proceedings, ITS, 2018
- BABIEL, G.: Bordnetze und Powermanagement, Springer Verlag, 2019

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Alternative, Electro and Hybrid Drives	2,0	Lecture	german
	1,0	Exercise	german

Title	Race cars		
Number	2534070	**Module version**	
Shorttext	MB-FZT-07	**Language**	german
Frequency of offer	only in the winter term	**Teaching unit**	Fakultät für Maschinenbau
Module duration	1	**Institution**	Institut für Fahrzeugtechnik
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Roman Henze
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examination	1 Examination element: written exam (90 min)		
Course achievement			

Contents

- Historical overview of the development of racing vehicles and racing series
- associations and regulations in motorsports
- race tires
- racecar aerodynamics
- suspension and differential locks
- safety in motorsports

Objective qualification

After completing the module, students are able to work on basic questions about the use of vehicles in motorsport. They know basic aspects of the motor sport regulations and are able to assess their compliance based on the analysis of specific technical implementations. The students understand how longitudinal and lateral forces are transmitted by racing tires and are able to assess the adhesion potential depending on air pressure and tire camber and evaluate appropriate measures to optimize performance. The students know the driving dynamics basics of racing vehicles and are able to analyze and assess the influence of setup changes on driving behavior. The students understand the influence of aerodynamics on the driving performance of racing vehicles and are able to examine, evaluate and specifically modify aerodynamic concepts for their driving behavior. Students are familiar with chassis designs and geometries and can name specific advantages and disadvantages. You also understand the relationship between aerodynamics and chassis and can always assess driving behavior. In addition, the students know essential aspects of motor sport safety and motor sport history and are able to name appropriate milestones.

Literature

- FROEMMIG, L.: Grundkurs Rennwagentechnik. 1. Auflage. Springer, 2019.
- HANEY, P.: The Racing & High Performance Tire, SAE Publications Group, 1. Aufl. 2003
- HUCHO, H (Hrsg.): Aerodynamik des Automobils Vieweg & Sohn, 5. Auflage 2005
- KATZ, J: Race Car Aerodynamics # Designing for Speed, Bentley Publishers, 2. Aufl. 2006
- MILLIKEN, W.F., MILLIKEN D.L.: Race Car Vehicle Dynamics, SAE Publications Group, 1. Aufl. 1995
- McBEATH, S..: Formel 1 Aerodynamik, Motorbuchverlag, 1. Aufl., Stuttgart 2001
- PIOLA, G.: Formula 1 # Technical Analysis (diverse Jahrgänge), Goirgio Nada Editore
- SMITH, C.: Tune to win Aero Publishers Inc., 1. Aufl., 1978 STANIFORTH, A.: Competition Car Suspension Haynes, 4. Aufl., 2006

- TIPLER, J.: Lotus 78 and 79 # The Ground Effect Cars, The Crowood Press Ltd, 1. Aufl., Ramsbury 2003
- TREYMANE, D.: The Science of Formula One Design Haynes, 2. Aufl., 2006 WRIGHT, P.:Formula 1 Technology; SAE Publications Group, 1. Auflage, 2001
- ABBOT, I.H.; v. DOENHOFF, A.E.: Theory of Wing Sections, Dover Publications, 2. korrigierte Aufl. 1959

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Related courses			
Rules for the choice of courses			
Both courses have to be attended			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture	german

Title	Vehicle Dynamics		
Number	2534210	**Module version**	
Shorttext	MB-FZT-21	**Language**	german
Frequency of offer	only in the winter term	**Teaching unit**	Fakultät für Maschinenbau
Module duration	1	**Institution**	Institut für Fahrzeugtechnik
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Roman Henze
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examination	written exam (90 min)		
Course achievement			

Contents

- vehicle movement and forces
- tyre characteristics
- (self-)steering behavior
- linear single-track model
- double-track model (influence of dynamic wheel loads, roll behavior, kinematics and elasto-kinematics)
- driving behaviour (steady-state, combined longitudinal and lateral dynamics, dynamic behaviour)
- active chassis systems

Objective qualification

After completion of this module, students will be able to analyze complex questions regarding the lateral dynamic driving behavior of passenger cars. They are able to describe and explain the influences of tyres, steering and chassis on driving dynamics. Students can analyze and evaluate simulation and measurement data from stationary and dynamic driving maneuvers. They also have the necessary knowledge to develop vehicle models of varying complexity to meet specific requirements. Students can apply the vehicle dynamics fundamentals and models for conceptual design of tyre, steering and chassis characteristics. Furthermore, they are able to assess the influence of active chassis systems on driving behaviour. Thus, students are able to communicate and argue professionally with specialists in vehicle dynamics and chassis technology.

Literature

BRAESS, H.H., SEIFERT, U. (HRSG): Handbuch der Kraftfahrzeugtechnik, Vieweg Verlag, 2011
MITSCHKE, M., WALLENTOWITZ, H.: Dynamik der Kraftfahrzeuge, 4. Auflage, 2004
HEISING, B., ERSOY, M.: Fahrwerkhandbuch # Grundlagen, Fahrdynamik, Komponenten, Systeme, Mechatronik, Perspektiven, ATZ/MTZ-Fachbuch, Vieweg, 2007 REIMPELL, J.: Fahrwerktechnik Grundlagen, 5. Auflage. Vogel Buchverlag, 2005
MATSCHINSKY, W.: Radführung der Straßenfahrzeuge # Kinematik, Elasto-Kinematik und Konstruktion, Springer, 2007
Trzesniowski, M.: Rennwagentechnik # Grundlagen, Konstruktion, Komponenten, Systeme, Praxis | ATZ/MTZ-Fachbuch, Vieweg+Teubner, 2010
ISERMANN, R.: Fahrdynamik-Regelung # Modellbildung, Fahrerassistenzsysteme, Mechatronik, ATZ/MTZ-Fachbuch, Vieweg, 2006 SCHRAMM, D., HILLER, M.,BARDINI,R.: Modellbildung und Simulation der

Dynamik von Kraftfahrzeugen, Springer, 2010 HALFMANN, C., HOLZMANN, H.: Adaptive Modell für die Kraftfahrzeugtechnik, Springer, 2003 GILLESPIE, T.: Fundamentals of Vehicle Dynamics, SAE, 1992
NIERSMANN, A.: Modellbasierte Fahrwerkauslegung und #optimierung, Schriftenreihe des Institut für Fahrzeugtechnik TU Braunschweig, Herausgegeben von Prof. Dr.-Ing. Ferit Küçükay, Shaker Verlag, 2012
HUNEKE, M.: Fahrverhaltensbewertung mit anwendungsspezifischen Fahrdynamik, Schriftenreihe des Institut für Fahrzeugtechnik TU Braunschweig, Herausgegeben von Prof. Dr.-Ing. Ferit Küçükay, Shaker Verlag 2012
FRÖMMIG, L.: Simulation und fahrdynamische Analyse querverteilender Antriebssysteme, Schriftenreihe des Institut für Fahrzeugtechnik TU Braunschweig, Herausgegeben von Prof. Dr.-Ing. Ferit Küçükay, Shaker Verlag, 2012
HENZE, R.: Beurteilung von Fahrzeugen mit Hilfe eines Fahrermodells, Schriftenreihe des Institut für Fahrzeugtechnik TU Braunschweig, Herausgegeben von Prof. Dr.-Ing. Ferit Küçükay, Shaker Verlag, 2004
DIEBOLD, J., SCHINDLER W., et al.: Einspurmodell für die Fahrdynamiksimulation und #analyse,ATZ online, Ausgabe 06/11
PACEJKA, H.B.; BAKKER, E.: The Magic Formula Tyre Model, Taylor&Francis, 1993.
PACEJKA, H.B.: Tyre and Vehilce Dynamics, 3rd edition, Butterworth-Heinemann, 2012
PFEFFER, P., HARRER, M.: Lenkungshandbuch, Vieweg-Teubner, 2011
HUCHO, W.H.: Aerodynamik des Automobils, Vieweg-Teubner, Wiesbaden 2005
WALLENTOWITZ, H., HOLTSCHULZE,J., HOLLE,M.: Fahrer-Fahrzeug-Seitenwind, VDI-Tagung Reifen-Fahrwerk-Fahrbahn, Hannover, 2001
RIEKERT, P., SCHNUCK, T.E.: Zur Fahrdynamik des gummibereiften Kraftfahrzeuges, Ingenieur-Archiv, XI Band, Heft 3, 1940

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Related courses			
Rules for the choice of courses			
Both courses have to be attended.			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture	german
	1,0	Exercise	german

Title	Basics of Automotive Engineering		
Number	2534250	**Module version**	
Shorttext	MB-FZT-25	**Language**	german
Frequency of offer	only in the winter term	**Teaching unit**	Fakultät für Maschinen-bau
Module duration	1	**Institution**	Institut für Fahrzeug-technik
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Roman Henze
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Recommended requirements	There are no requirements for attending this module.		
Expected performance/ Type of examina-tion	1 examination element: written exam (90 min)		
Course achievement			

Contents

- Driving resistances and traction force equation
- Adhesion ratios
- Clutch and transmission
- Drive concepts
- Energy consumption
- Braking
- Basics of lateral vehicle dynamics
- Kinematics and forces in lateral dynamics
- Self-steering-effect, influences of parameters
- Vehicle modelling
- Vertical vehicle dynamics
- Ride comfort and driving safety

Objective qualification

The students are capable to analyse independently the longitudinal, lateral and vertical dynamic vehicle behavior in various driving situations. With the help of different calculation approaches they are able to analyse and evaluate the vehicle behavior. The students can recall automotive engineering terms and can explain their peculiarities. They are capable of classifying and analyzing the influences of typical vehicle parameters in a comprehensive survey of the vehicle’s dynamic behavior. The students can interpret the basics of computer-aided modelling of the dynamic behavior of motor vehicles and can implement the methodical knowledge to optimize complex products. Based on various vehicle models they are able to check and argument independently when to use which model for each complex problem. Due to this, the students can communicate in technical discussions with specialists from the automotive sector and independently evaluate statements based on their learned knowledge in the area of longitudinal, lateral and vertical dynamic vehicle behavior.

Literature

1. MITSCHKE, M.; WALLENTOWITZ, H.: Dynamik der Kraftfahrzeuge, 4. Auflage, Berlin: Springer Verlag, 2014

2. HAKEN, K.-L.: Grundlagen der Kraftfahrzeugtechnik, 2. Auflage, München: Hanser Verlag, September 2011
3. FISCHER, R., KÜÇÜKAY, F., JÜRGENS, G., POLLAK, B.: Das Getriebebuch (Der Fahrzeugantrieb), 2. Auflage, Berlin, Springer Verlag, 2016
4. ZOMOTOR, A.: Fahrwerktechik: Fahrverhalten, 2. Aktualisierte Auflage, Würzburg: Vogel Business Media, 1991
5. KÜÇÜKAY, F.: Grundlagen der Fahrzeugtechnik, Skriptum zur Vorlesung, Institut für Fahrzeugtechnik
6. HENZE, R.: Handlingabstimmung und Objektivierung, Skriptum zur Vorlesung, Sommersemester 2019

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Related courses			
Rules for the choice of courses			
Both courses have to be attended.			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture	german
	1,0	Exercise	german

Title	Electronic Engine Controls		
Number	2536080	**Module version**	
Shorttext	MB-IVB-08	**Language**	german
Frequency of offer	only in the summer term	**Teaching unit**	Fakultät für Maschinenbau
Module duration	1	**Institution**	Institut für Verbrennungskraftmaschinen und Brennstoffzellen
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Peter Eilts
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Recommended requirements	• Basic understanding of physical relationships • Fundamentals of Thermodynamics • Module: "Internal Combustion Engine Basics" (or similar)		
Expected performance/ Type of examination	written exam (120 min)		
Course achievement			

Contents

- Electronics in the vehicle: Control units, Bus systems
- Objectives of electronic control and regulation: Exhaust gas, Fuel consumption, Driving behaviour
- Injection control: General correlations, Sensors for detecting the crankshaft and camshaft position, Sensors for air survey, General correlations of mixture formation, Methods of injection control, Functions of the injection control, Control unit hardware, Injection systems
- Lambda control: Principle of lambda control, Oxygen sensors, Controller functions
- Adaptation
- OBD

Objective qualification

The students can name the structure, function, calculation and technical details of internal combustion engines. They are able to understand the methods and components of electronic engine management and to explain the interrelationships between the control and regulation of engine processes. Students are able to apply scientific statements and methods of electronic engine management to concrete, practical problems. The Students gain an insight into the main areas of development of the components and processes of electronic engine management and are able to understand and assess new developments with regard to technical, economic and environmental aspects. They are capable of professional communication with specialists in engine technology.

Literature

Urlaub, A.: Verbrennungsmotoren; Springer Verlag (1994)
Pischinger, R.: Thermodynamik der Verbrennungskraftmaschine, Die Verbrennungskraftmaschine, Band 5; Springer-Verlag (2002) Küntscher, V.; Kraftfahrzeugmotoren # Auslegung und Konstruktion; Vogel Verlag (2014)

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**

Title	Internal Combustion Engine Fundamentals		
Number	2536140	**Module version**	
Shorttext	MB-IVB-14	**Language**	german
Frequency of offer	only in the summer term	**Teaching unit**	Fakultät für Maschinen-bau
Module duration	1	**Institution**	Institut für Verbren-nungskraftmaschinen und Brennstoffzellen
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Peter Eilts
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examina-tion	written exam (120 min)		
Course achievement			

Contents

- Introduction
Historical development
Economic relevance
Classification of internal combustion engines
- Engine cycles
Comparison processes
The perfect engine
- The real engine
Gas exchange
Quality grade
Volumetric efficiency
Mechanical efficiency
Effective engine operating data
Supercharging
Engine operating data
- Spark ignition engines
Mixture formation
Ignition systems
Ignition and combustion in a spark ignition engine
Reaction mechanisms
Emissions and exhaust gas aftertreatment
- Diesel engines
Mixture formation
Inflammation and combustion
Reaction mechanisms
Emissions and exhaust gas aftertreatment in diesel engines
- Fuels
Gasoline
Diesel fuels
Alternative fuels
- Engine mechanics

Motion conditions on the crank train Inertia force
Objective qualification
The students can name the structure and technical details of internal combustion engines. They are able to understand the function and the calculation of internal combustion engines and are able to explain the relationships of the energy conversion in internal combustion engines. The Students can apply scientific statements and procedures on internal combustion engines to specific, practical problems. The students gain an insight into the development focus of internal combustion engines and are able to understand and assess new developments regarding the technical, economic and environmental aspects. They are capable of professional communication with specialists in engine technology.
Literature
Urlaub, A.: Verbrennungsmotoren; Springer Verlag (1994) Merker, G.; et al.: Grundlagen Verbrennungsmotoren, Vieweg+Teubner Verlag (2012) Küntscher, V.: Kraftfahrzeugmotoren; Verlag Technik, Berlin (1995)

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**

Title	Traffic Control Engineering		
Number	2539400	**Module version**	
Shorttext	MB-VuA-40	**Language**	german
Frequency of offer	only in the winter term	**Teaching unit**	Fakultät für Maschinenbau
Module duration	1	**Institution**	Institut für Intermodale Transport- und Logistiksysteme
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Karsten Lemmer
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Expected performance/ Type of examination	1 examination element: written exam (120 min)		
Course achievement	written report on practical exercices		

Contents

- traffic engineering;
- terminology and characteristics of traffic elements;
- classification of traffic;
- traffic objects, vehicles, infrastructure, production and distribution concepts;
- operation and network management, traffic flow management, traffic organization;
- traffic physics;
- distribution of traffic, single vehicle control and information management.

Objective qualification

Students are able to analyse the functions, structures and technologies of traffic control systems as well as the physical, technological and operational fundamentals of land vehicles and infrastructure and to evaluate these using technical examples from the operations of road and railway transport. In doing so, they apply the technical terminology and the basics of transport technology as well as specific definitions and model concepts of road and rail transport and use them when working on technical examples. Students have the capacity of transferring what they have learned to the practical and operational conditions as they are presented in practical exercises at vehicle manufacturers and infrastructure facilities as well as operators of road and rail transport. They are able to explain traffic control concepts related to those practical examples. Students analyse the technical possibilities of influencing individual vehicle movement, traffic flows and traffic streams in mono- and multimodal networks and derive suitable solutions on the basis of case studies. Building on that, they discuss dynamic model concepts based on microscopic physical models up to aggregated flow models using practical examples and are able to apply those methods, means of description and tools to reproduce and analyse behaviour patterns with the aid of simulation models.

Literature

Remark

The lecture traffic control engineering provides a systematic overview of the basics for understanding of transport systems and their functions and structures as well as their technical realization in ground transpor-

tation. It is supplemented by practical field trips to vehicle manufacturers, infrastructure facilities and operators of road and rail transport.

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Traffic System Engineering	2,0	Lecture	german
Traffic System Engineering	2,0	Exercise	german

Title	Internal Combustion Engines and Fuel Cells		
Number	2536200	**Module version**	
Shorttext	MB-IVB-20	**Language**	german
Frequency of offer	only in the summer term	**Teaching unit**	Fakultät für Maschinen-bau
Module duration	1	**Institution**	Institut für Verbren-nungskraftmaschinen und Brennstoffzellen
Hours per Week / ECTS	3 / 5,0	**Module owner**	Prof. Dr. Peter Eilts
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Recommended requirements	Basic knowledge of physical connections - fundamentals of thermodynamics.		
Expected performance/ Type of examina-tion	1 examination element: written exam, 120 minutes		
Course achievement			

Contents

- Introduction Historical development Economic relevance Classification of internal combustion engines
- Engine cycles Comparison processes The perfect engine
- The real engine Gas exchange Quality grade Volumetric efficiency Mechanical efficiency Effective engine operating data Supercharging Engine operating data
- Spark ignition engines Mixture formation Ignition systems Ignition and combustion in a spark ignition engine Reaction mechanisms Emissions and exhaust gas aftertreatment
- Diesel engines Mixture formation Inflammation and combustion Reaction mechanisms Emissions and exhaust gas aftertreatment in diesel engines
- Fuels Gasoline Diesel fuels Alternative fuels
- Engine mechanics Motion conditions on the crank train Inertia force

Objective qualification

The Students can name the structure and technical details of internal combustion engines. They are able to understand the function and the calculation of internal combustion engines and are able to explain the relationships of the energy conversion in internal combustion engines. The Students can apply scientific statements and procedures on internal combustion engines to specific, practical problems. The students gain an insight into the development focus of internal combustion engines and are able to understand and assess new developments regarding the technical, economic and environmental aspects. They are capable of professional communication with specialists in engine technology.

Literature

Urlaub, A.: Verbrennungsmotoren; Springer Verlag (1994)
Merker, G.; et al.: Grundlagen Verbrennungsmotoren, Vieweg+Teubner Verlag (2012)
Küntscher, V.: Kraftfahrzeugmotoren; Verlag Technik, Berlin (1995)

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	2,0	Lecture	german
	1,0	Exercise	german

Title	Traffic Engineering		
Number	4301920	**Module version**	
Shorttext	BAU-STD2-9	**Language**	german
Frequency of offer		**Teaching unit**	Fakultät Architektur, Bauingenieurwesen und Umweltwissenschaften Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration		**Institution**	
Hours per Week / ECTS	0 / 6,0	**Module owner**	
Workload (h)			
Class attendance (h)		**Self studying (h)**	
Compulsory requirements			
Expected performance/ Type of examination			
Course achievement			
Contents			
Objective qualification			
Literature			

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
	4,0	Lecture/Exercise	german

Title	electrotechnical laboratory practical course specialization battery technologies		
Number	2423000000	**Module version**	
Shorttext		**Language**	german
Frequency of offer	only in the winter term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	1	**Institution**	elenia Institut für Hochspannungstechnik und Energiesysteme
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Michael Kurrat
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Expected performance/ Type of examination	For the seminar: portfolio in addition to passed lab work		
Course achievement	Lab work: successful participation in four lab experiments incl. written report		

Contents

Practical experiments in the areas of:
- Formation and post-mortem analysis
- Electrochemical characterizations
- Pressure analysis
- Simulation and modeling

The practical experiments include preparation, experimental work, colloquium and written elaboration. This knowledge will be deepened during the seminar.

Objective qualification

Students know and understand in-depth methods of battery technology, including the characterization, analysis and simulation of batteries. Students will be able to apply the basic knowledge they have already acquired in other modules, e.g. the structure and function of storage systems. They have the ability to collect, document and evaluate experimental data from various battery test cells and to cooperate successfully with fellow students. Students are able to make scientifically sound judgments in the context of battery technologies. Draw new conclusions from their own results and the state of knowledge in the literature. This scientific work must be presented orally and in writing.

Literature

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
seminar - electrotechnical laboratory practical course specialization battery technologies	2,0	Seminar	german
laboratory - electrotechnical laboratory practical course specialization battery technologies	2,0	Laboratory	german

Title	Automation Engineering with Laboratory		
Number	2539000060	**Module version**	
Shorttext		**Language**	english
Frequency of offer	only in the winter term	**Teaching unit**	Fakultät für Maschinenbau
Module duration	1	**Institution**	Institut für Intermodale Transport- und Logistiksysteme
Hours per Week / ECTS	6 / 7,0	**Module owner**	Prof. Dr. Jürgen Pannek
Workload (h)	210		
Class attendance (h)	56	**Self studying (h)**	154
Compulsory requirements			
Recommended requirements	Control Engineering		
Expected performance/ Type of examination	1 examination elment: written exam+ (90 min) or oral exam+ (30 min)		
Course achievement	2 course achievements: a) optional course achievement: Creation and documentation of a computer or software program (on request, the result of the coursework within the framework of the exam+ is included in the assessment at 20%) b) Compulsory course achievement: colloquium or report (organized in groups) on the completed laboratory experiments		

Contents

Lecture/Tutorial:
- Aim of automation engineering
- Basics, tasks and methods of automation
- Coupling and hierarchies of systems
- Information and information management
- Control, modularization and standardization in automation
- Digitalization for industrial internet, industrial could and CPS
- Basics of knowledge management, industrial big data and decision support

Laboratory:
- Computer-aided design of an automation system
- Realization of an automation task with a PLC
- Modelling and simulation of robots
- Robot programming
- NC programming - production of a turned part
- Control of an automated guided vehicle (AGV)

Objective qualification

After having successfully completed the lecture Automation Engineering, the students will have a sound basic knowledge of term and methods within the area of automation engineering and are able to reproduce, describe and apply the latter. The students can explain modeling, classification, control and coupling of

technical processes. They are also able to analyze information handling in technical processes and information transfer. Students are capable to determine the organizational, distribution and communication structures of automation systems. In addition, the students can describe basic aspects of modularization, standardization, and automation. The students understand the digitization topics industrial internet, cloud and cyber-physical systems. As such, the students can reproduce the approaches of knowledge management, industrial big data, and decision support. The laboratory enables students to independently apply the acquired skills to simple, practical tasks in various automation domains.

Literature

- Lunze, J.: Automatisierungstechnik. 5. Auflage. DeGruyter (2020);
- Plenk,V.: Grundlagen der Automatisierungstechnik kompakt, Springer (2019);
- Lai, C.: Intelligent Manufacturing, Springer (2022);
- LangmannN, C.; Turi, D.: Robotic process automation – Digitalisierung und Automatisierung von Prozessen, Springer (2020);
- Stjepandic, J.; Sommer, M.; Denkena, B.: DigiTwin: An approach for production process optimization in a built environment, Springer (2022)

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Related courses

Rules for the choice of courses

Compulsory attendance

Name of the course	SWS	Eventtype	Language
Automation Engineering	2,0	Laboratory	english
Automation Engineering	2,0	Lecture	english
Automation Engineering	2,0	Exercise	english

Title	Application of Control Engineering Methods		
Number	2412000010	**Module version**	
Shorttext		**Language**	german
Frequency of offer	only in the winter term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	1	**Institution**	Institut für Regelungstechnik
Hours per Week / ECTS	4 / 5,0	**Module owner**	Prof. Dr. Markus Maurer
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Recommended requirements	Fundamentals of Control Engineering (can be done parallel), max number of participants: 16		
Expected performance/ Type of examination	Written exam (60 min) or oral exam (30 min)		
Course achievement			

Contents

Modeling, representation in the time and frequency domain, computer-aided solution of differential equations, step responses, impulse responses, Laplace transformation, Bode diagram, locus curve, typical individual elements of controlled systems, transfer function, controller design of standard controllers, equivalent time constant, cascade control, computer-aided tools for control engineering tasks

Objective qualification

After completing the module, students will have basic knowledge in the field of linear control engineering as well as in-depth knowledge of the use of computer-aided applications for simulation, controller design and the application of the theoretical content taught. They are familiar with the properties and dynamic behavior of basic control engineering components and methods of classical controller design. They understand the concepts for describing linear and simple non-linear dynamic systems in the time and frequency domain as well as the concept of the Laplace transformation. You will be able to model linear time-invariant systems with concentrated memories and design standard controllers in the frequency domain. This includes the design using pole placement, the modelling of equivalent time constants, as well as working in the Bode diagram and the design of multi-loop controller structures.

Literature

Remark

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**
Application of Control Engineering Methods	2,0	Lecture	german
Application of Control Engineering Methods	2,0	Exercise	german

Professionalization

Title	Professionalisation		
Number	2499620	**Module version**	
Shorttext	ET-STDE-62	**Language**	german
Frequency of offer	every term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	2	**Institution**	
Hours per Week / ECTS	6 / 15,0	**Module owner**	
Workload (h)	450		
Class attendance (h)	168	**Self studying (h)**	282
Compulsory requirements			
Expected performance/ Type of examination			
Course achievement	1. coursework seminar presentation: presentation according to § 4 para. 15 2. coursework language skills: according to the requirements of the course taken from the pool 3. coursework Master's team project: The examination requirements for the Master's team project correspond to the draft (Section 9 (6) APO). A written project plan must be submitted for the Master's team project at the beginning, which should be updated during the course of the project. The comparison between initial planning and actual progress must be presented and justified in the final report. The results of the Master's team project must be summarised in a report in which the individual contributions of the project participants are identified. Furthermore, the results must be presented in a presentation (§ 4 para. 15 BPO). 4. final presentation in accordance with the separate regulations "Internship Guidelines of the FK Electrical Engineering, Information Technology, Physics" in the version valid at the beginning of the degree programme.		

Contents

The individual description of the course applies in each case. Supplementary notes and comments in the individual course descriptions must be taken into account.

Objective qualification

Seminar: Independent familiarisation, preparation and presentation of a topic, determining the effect of one's own presentation on other students, learning key skills such as presentation techniques and rhetorical skills

In-depth language skills for use in research and development

In the team project, the acquired methods for system analysis and design are implemented in a practical example of current research topics. Project-orientated teamwork and an interdisciplinary approach are taught.

The industrial internship provides in-depth preparation for professional life by working directly in an industrial company for 8 weeks. Students gain an insight into organisational and operational processes and structures as well as the working methods of engineering in industrial companies. Within the wide variety and breadth of structural areas (e.g. research, development, production, sales,...) and fields of activity (e.g. hardware or software development, production planning, quality assurance, sales, (project) management,...) in an industrial company, an exemplary selection with in-depth familiarisation with one or a few of these areas or fields is expected.

The aim of the module is to further develop patterns of action and techniques appropriate to the situation and task as well as to further develop and adapt the methodological skills taught in the degree programme in the engineering solution of technical problems. Students develop their interdisciplinary knowledge and skills (e.g. dialogue and negotiation skills, presentation techniques, documentation, etc.), for example by participating in meetings or by being involved in conceptual, planning or management tasks. They also carry out and represent their own engineering activities (e.g. in conceptual planning, development or quality assurance) independently. In doing so, they apply the technical knowledge and skills acquired during their studies to practical tasks in an industrial environment.
The activities carried out as part of the industrial internship must be presented in an ungraded presentation.

Literature

Remark

The Master's team project is carried out in groups of at least 3 students who work on an overarching topic to design an electronic system in automotive, aerospace and aeronautical engineering according to its components. The team project should be carried out during the semester and is limited to one semester.
Language: German or English

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Related courses

Rules for the choice of courses

The following components (courses) must be taken:

1. seminar

2. course on in-depth language skills (attention: from language level B2, English)

3. master team project or industrial internship

Compulsory attendance

Name of the course	SWS	Eventtype	Language
	3,0	Seminar	german
Student Seminar Internet of Things	3,0	Seminar	english german

Literature

Will be announced during seminar

Seminar Algorithmics (Bachelor & Master)	3,0	Seminar	german
Literature			
Die Literaturquellen variieren - je nach gewähltem Seminarthema.			

Seminar Software Engineering and Automotive Informatics (Master)	3,0	Seminar	english german
Literature			
Die Literaturquellen variieren - je nach gewähltem Seminarthema.			

Master's Thesis

Title	Master's Thesis		
Number	2499510	**Module version**	
Shorttext	ET-STDE-51	**Language**	german
Frequency of offer	every term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	1	**Institution**	
Hours per Week / ECTS	0 / 30,0	**Module owner**	Studiendekan Elektrotechnik
Workload (h)	900		
Class attendance (h)		**Self studying (h)**	
Compulsory requirements			
Expected performance/ Type of examination	• Preparation of the Master's thesis (28 credits) • Presentation (according to § 4 para. 14 BPO) (2 credits) The assessment of the presentation is included in the overall grade of the final module with double weighting.		
Course achievement			

Contents

individual

Objective qualification

With the successful completion of the final thesis (§ 14 APO) and the presentation, the student demonstrates that he/she is able to work independently on a problem from the chosen subject area using scientific methods within a specified period of time. The qualification objectives of the degree program (Annex 1, § 2 APO) are reflected in the implementation and results of the final thesis with regard to the following components:

- Independent familiarisation with and scientific methodical processing of a topic fundamentally relevant to further development and research in the field of electrical engineering
- Literature research and presentation of the state of the art
- Development of new solution approaches for a scientific problem
- Presentation of the approach and results in the form of a paper
- Presentation of the main results in a comprehensible form
- Consolidation and refinement of key qualifications: management of an own project, presentation techniques and rhetorical skills

Literature

Remark

The Master's thesis is credited with 28 credits and the presentation with 2 credits; the assessment of the presentation is included in the overall grade of the final module with double weighting.

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Related courses			
Rules for the choice of courses			
Compulsory attendance			
Name of the course	**SWS**	**Eventtype**	**Language**