Technical University of Applied Sciences Augsburg

Faculty of Electrical Engineering

Master Program

Electrical Engineering (M.Engineering.)

Module Catalogue

SoSe 2025

created: March 14, 2025

Table of Contents

Advanced Control Theory

ID	ACT
Study section	Catalogue I
Responsible lecturer	Prof. Dr. Florian Kerber
Mandatory/elective	Elective
Rotation	Summer term, annually
Duration	1 term
Course	Advanced Control Theory
CP / SWS	5 CP, 4 SWS
Workload	Total 5 CP x 25 h = 125 h thereof attendance 47 h, self-study 78 h
Study/Examination Performance	according to Syllabus and Examination Regulations and Record of Examinations Schedule
Marking	according §20 APO in its relevant version
Prerequisites	none
Applicability	Module to obtain essential credit points
Teaching language	English
Teaching/Learning method	Seminar-like lecture, exercise, lab tutorial

Advanced Control Theory

Contents	- Modelling and simulation of dynamical systems: differential equations, state space models, transfer functions. - Properties of dynamical systems: stability, controllability, observability, dissipativity. - State space control for linear systems: feedback control methods, in particular pole placement and optimal LQR control - Digital control systems: z transform, analysis and system properties, controller cesign - Design of control systems with MATLAB and Simulink: real time systems, rapid control prototyping (lab tutorial and mini projects). - Special topics in applied control, in particular trajectory planning and sensor driven control for autonomous vehicles and robotic systems.
Module objec-tives	**Learning outcomes** - Perceive the behaviour and determine properties of complex dynamical control systems. - Have a thorough acquaintance with modern feedback control strategies and techniques. - Employ effectively modern control design methodologies and tools for the design and implementation of feedback controllers. **Knowledge Targets** - Design control systems to meet a particular specification. - Analyse complex dynamical systems; detect problems and find solutions. - Design and test feedback control systems. **Capabilities** - Handle complex systems beyond the comprehension of one single human being through communication, control and teamwork. - Perform effectively within a group in the conduct of a practical control design project. - Know the benefits and limitations of modern control techniques for solving practical engineering tasks

Advanced Control Theory

Literature	- Åström,. K. J.; Murray, R.: Feedback Systems: An Introduction for Scientists and Engineers Princeton University Press 2021 - van der Schaft, A; Jeltsema, D.: Port-Hamiltonian Systems Theory: An Introductory Overview 2014 - Dorf, R. C.; Bishop, R. H.: Modern Control Systems, Addison-Wesley 2010 - Franklin, G. F. ; Powell, J. D.; Emami-Naeini A.: Feedback Control of Dynamic Systems. Addison-Wesley, 2010 - Friedland, B.: Control System Design - An Introduction to State-Space Methods, McGraw-Hill 2005 - Messner, W C & D. M. Tilbury: Control Tutorials for MATLAB and Simulink: A Web-Based Approach, Addison-Wesley 1998 - Tewari, A: Modern Control Design: with MATLAB and Simulink, John Wiley & Sons 2002

Automation	
ID	AUT
Study section	Catalogue I
Responsible lecturer	Prof. Dr. Peter Kopystynski
Mandatory/elective	Elective
Rotation	Summer term, annually
Duration	1 term
Course	Automation
CP / SWS	5 CP, 4 SWS
Workload	Total 5 CP x 25 h = 125 h thereof attendance 47 h, self-study 78 h
Study/Examination Performance	according to Syllabus and Examination Regulations and Record of Examinations Schedule
Marking	according §20 APO in its relevant version
Prerequisites	none
Applicability	Module to obtain essential credit points
Teaching language	English
Teaching/Learning method	Seminar-like lecture, exercise

Automation	
Contents	- Petri Net basics, timed models, application in programming tools for programmable controllers. - Introduction to stochastic systems, discrete- and continuous-time Markov chains. - Review of the programming concept for PLCs according to the norm IEC 61131-3. - Connectivity between SoftPLCs, Input/Output devices and commercial applications, e.g. visualisation based on OPC or industrial ethernet. - Design and verification of safety related programmable control systems according to European standards. - Modelling of nonlinear characteristics of temperature, magnetic, optic and chemical sensors. - Modelling of dynamic effects and limitations of sensors, e.g. cut-off frequency and parasitic elements

Automation

Module objectives	**Learning outcomes** - Become familiar with discrete event systems as the basis for modelling automation problems. - Be able to treat random effects in automation problems. - Perceive the principles of PLC networks. - Understand the principles and limitations of sensors and sensor systems. **Knowledge Targets** - Use simulation software to analyse the behaviour of a discrete event system. - Use PLC programming tools based on a graphical description of a discrete event system. - Configure a network of Programmable Logic Controllers connected via fieldbus and /or Ethernet. - Develop controller software according to the rules of IEC 61131-3. - Simulate sensors and circuits (e.g. with PSPICE or LabView) - Analyze data sheets & select appropriate components for automation & control systems **Capabilities** - Appreciate the value of formal description methods as the basis for problem solving. - Know the benefits and limitations of simulation as an engineering tool. - Perform effectively within a group in the conduct of a practical project.

Automation

Literature	- Cassandras, Lafortune: Introduction to Discrete Event Systems, Kluwer Academic Press 1999 - David, Alla: Discrete, Continuous and Hybrid Petri Nets, Springer 2005 - Tornambe: Discrete-Event System Theory, World Scientific 1995 - John, Tiegelkamp: IEC 61131-3: Programming Industrial Automation Systems, Springer 2010 - Iwanitz, Lange, Burke: OPC : From Data Access to Implementation and Application, Hüthig 2010 - Hauke, et al.: Functional safety of machine controls -- Application of EN ISO 13849, DGUV 2009 - Fitzpatrick: Analogue Design and Simulation Using Orcad Capture and Pspice, Newnes 2011 - Bishop: LabVIEW 2009 Student Edition, Prentice Hall 2009

Electric Power Systems

ID	EPS
Study section	Catalogue I
Responsible lecturer	Prof. Dr. Michael Finkel
Mandatory/elective	Elective
Rotation	Summer term, annually
Duration	1 term
Course	Electric Power Systems
CP / SWS	5 CP, 4 SWS
Workload	Total 5 CP x 25 h = 125 h thereof attendance 47 h, self-study 78 h
Study/Examination Performance	according to Syllabus and Examination Regulations and Record of Examinations Schedule
Marking	according §20 APO in its relevant version
Prerequisites	Detailed knowledge in basic structure of electric power supply systems and network components such as substations, cable, overhead lines and circuit breakers
Applicability	Module to obtain essential credit points
Teaching language	English
Teaching/Learning method	Seminar-like lecture, exercise

Electric Power Systems

Contents	- Basics of electric power systems
	  - General structure of electric power systems
	  - Current developments in electricity supply
	  - Power system economics
	  - Renewable generation technologies
	  - Challenges with integration of renewable generation
	- Network components
	  - Transformers
	  - Operational behaviour of Power Lines
	  - Reactive Power Compensation in High Voltage Grids
	  - High Voltage DC transmission
	- Transmission and distribution system planning
	  - Load-flow, methods of network calculation
	  - Network protection
	- Network operation
	  - Monitoring and control
	  - Reliability and stability
	  - Smart Grids
	- Energy Storage Systems

Electric Power Systems

Module objectives	**Learning outcomes** - Understand the basis of operation of modern electrical power systems. - Be able to calculate effects in electrical power systems. - Perceive the principles of innovative solutions in electricity supply. - Know the components required for sustainable electricity supply systems. **Knowledge Targets** - Analyse energy transmission and distribution problems and identify appropriate solution methods. - Devise solutions for energy supply problems using state-of-the-art technologies. - Evaluate electricity networks - Adapt basic planning approaches to electricity systems. **Capabilities** - Demonstrate informed decision making skills whilst considering a range of impacts in supply systems. - Identify problems, produce and appraise solutions to network operational problems. - Use simulation software to configure power systems. - Appreciate the value of formal description methods as the basis for problem solving. - Know the benefits and limitations of simulation as an engineering tool. - Perform effectively within a group in a practical project.

Electric Power Systems

Literature	- ABB, Switchgear Manual, 11th edition, ABB, 2006. - B.M. Buchholz, Z. Styczynski, Smart Grids -- Fundamentals and Technologies in Electricity Networks, Springer 2014 - M. Finkel, Intended and Unintended Islanding of Distribution Grids, The Institution of Engineering and Technology (IET), 2024 - U. Häger, C. Rehtanz, N. Voropai (Editors), Monitoring, Control and Protection of Interconnected Power Systems, Springer 2014 - P. Kundur, Power System Stability and Control, McGraw-Hill, 1994, ISBN 0-07-035958-X. - CIGRE, technical brochure 475: Demand side integration, 2011 - In addition to many selected published papers in IEEE.

Selected Topics on Digital Communications	
ID	DC
Study section	Catalogue I
Responsible lecturer	Prof. Dr. Matthias Kamuf
Mandatory/elective	Elective
Rotation	Summer term, annually
Duration	1 term
Course	Selected Topics on Digital Communications
CP / SWS	5 CP, 4 SWS
Workload	Total 5 CP x 25 h = 125 h thereof attendance 47 h, self-study 78 h
Study/Examination Performance	according to Syllabus and Examination Regulations and Record of Examinations Schedule
Marking	according §20 APO in its relevant version
Prerequisites	Basic course on Signals and Systems
Applicability	Module to obtain essential credit points
Teaching language	English
Teaching/Learning method	Seminar-like lecture, practical exercise
Contents	*Modulation* e.g. transmission in lowpass vs. bandpass regime, single- vs. multi-carrier transmission, MIMO transmission modes *Signal processing algorithms* e.g. automatic gain control; receiver synchronisation; adaptive and non-adaptive digital filters and their application in channel estimation, equalisation, oversampling, resampling etc. *Implementations* FPGA implementations; transceiver architectures; quantisation

Selected Topics on Digital Communications

Module objectives	**Learning outcomes** - Understand the functionality and the limitation of modern algorithms and protocols for communication systems - Have a thorough acquaintance with writing and testing algorithms and protocols and also how to integrate them in an existing signal processing architecture - Develop simulation models of communication systems and their signal processing algorithms for simulation in frequency domain, time domain, floating point and fixed-point. - Develop implementations of signal processing algorithms on a programmable hardware platform. - Be aware of hardware limitations imposed on signal processing algorithms and find implementation choices which take these into account. **Knowledge Targets** - Read and comprehend technical specifications and block diagrams of communication systems. - Model, design, simulate, optimise, test and implement communication systems and their signal processing algorithms. - Critically evaluate choices of implementation of communication systems and their algorithms with regard to design effort, hardware effort, power consumption, and overall system cost. **Capabilities** - Use the available range of high-level languages for algorithm modeling, simulation and implementation of communication systems and their building blocks. - Improve oral and written communication skills. - Work effectively in a team. - Be able to think and work on different levels of abstraction.

Selected Topics on Digital Communications

Literature	- Rimoldi: Principles of Digital Communication, Cambridge, 2016 - Heath: Introduction to Wireless Digital Communication, Prentice Hall, 2017 - Haykin: Adaptive Filter Theory, Prentice Hall, 2001 - Tanenbaum et al.: Computer Networks, Prentice Hall, 2020

VLSI-Design

ID	VLSI
Study section	Catalogue I
Responsible lecturer	Prof. Dr. Friedrich Beckmann
Mandatory/elective	Elective
Rotation	Summer term, annually
Duration	1 term
Course	VLSI-Design
CP / SWS	5 CP, 4 SWS
Workload	Total 5 CP x 25 h = 125 h thereof attendance 47 h, self-study 78 h
Study/Examination Performance	according to Syllabus and Examination Regulations and Record of Examinations Schedule
Marking	according §20 APO in its relevant version
Prerequisites	none
Applicability	Module to obtain essential credit points
Teaching language	English
Teaching/Learning method	Seminar-like lecture, exercise

VLSI-Design

Contents	- Design Styles: Full custom design; standard cell approach; hardware and behaviour description entry approach; functional abstraction; rules and hints on decision-making. - Design Flow: Function entry; verification; timing analysis; synthesis layout; - Hierarchical Design Styles: Cells; blocks; buses; high-level hardware description language (HDL). - Hardware Description Language Entry: Behavioural, structural and functional function entry using VHDL. - CAD Tools: Compilation; simulation; synthesis; static timing analysis; routing. placement.; - Guide to verifying complex systems. Introduction to Testing: Manual and automatic test pattern generation. Design for Testability: rules; procedures; methods. - Management Issues: Splitting designs into blocks; releases and release management; bug tracking; design rules.

VLSI-Design

Module objectives	**Learning outcomes** - Become familiar with the design styles and the rules for current implementation approaches. - Write behavioural and structural code in a hardware description language according to a specification in natural language. - Handle complex hierarchical structures - Be aware of the limitations of functional verification and specify verification patterns. - Have a thorough acquaintance with the r oles of automatic testing and design for testability. **Knowledge Targets** - Read and comprehend technical specifications. - Design, code, simulate, synthesise and implement complex digital functions and systems. - Critically evaluate verification approaches, be aware of the limitations and risks, especially in life supporting systems. - Use the available range of CAD tools for HDL input, simulation, verification, synthesis, static timing analysis and layout. **Capabilities** - Recognise the inherent ambiguity of natural language in contrast to formal language - Handle complex systems beyond the comprehension of one single human being through abstraction, communication and teamwork - Appreciate the difference between functional verification, formal verification and falsification as well as the limitations in proving the correctness of theories and finding truth through simulation or testing.

VLSI-Design

Literature	- A. Eder: VHDL Short Course & Guide to Synthezisable Code, FHA Intranet 2005 - Barry Wilkinson: The Essence of Digital Design, Prentice Hall Europe 1998 - Ashenden: The Designer' s Guide to VHDL, Morgan Kaufman 2001 - William K. Lam: Hardware Design Verification: Simulation and Formal Method Based Approaches, Prentice Hall 2005

Cryptography and IT-Security	
ID	CS
Study section	Catalogue I
Responsible lecturer	Prof. Dr. Helia Hollmann, Prof. Dr. K. Werthschulte
Mandatory/elective	Elective
Rotation	Summer term, annually
Duration	1 Semester
Course	Cryptography and IT-Security
CP / SWS	5 CP, 4 SWS
Workload	Total 5 CP x 25 h = 125 h thereof attendance 47 h, self-study 78 h
Study/Examination Performance	according to Syllabus and Examination Regulations and Record of Examinations Schedule
Marking	according §20 APO in its relevant version
Prerequisites	none
Applicability	Module to obtain essential credit points
Teaching language	English
Teaching/Learning method	seminar-like lecture, practical exercises

Cryptography and IT-Security

Contents

1. Cryptography
   - Symmetric Cryptographic Algorithms
   - Asymmetric Cryptographic Algorithm
   - Digital Signature Algorithms
   - Key Exchange Protocols
   - Authentication Protocols
   - Secure Hash Algorithms
2. Security
   - Basic Terms
   - Protection Goals and attack classification
   - Critical infrastructures
   - Communication protocols
     - IT-networks
     - Field bus systems
     - Examples of network attacks
   - Attacks on device level
     - Introduction controlling units (x86/ARM)
     - Memory protection mechanisms
     - Runtime behaviour and memory management
     - Examples of attacks on device level
3. Basics of the ISO/IEC 62443

Cryptography and IT-Security

Module objec-tives	**Knowledge:** - students know the basic cryptographic algorithms and their purpose - students are able to name and explain the differences between symmetric and asymmetric cryptographic algorithms - students are able to describe common attacks on IT systems - students know the low level mechanisms of x86/ARM architectures for handling security - students know how executables can be manipulated and how to protect against it **Skills:** - students are able to analyze threats and risks of given IT systems - students are able to derive requirements for the application of cryptographic algorithms - students are able to analyse common industrial communication systems - students are able to analyse code and find deficiencies concerning security **Competences:** - students are able to develop secure communication and key management concepts - students are able to justify security measures in devices and networks - students are able to criticize and defend IT-security concepts - students can analyse basic attacks on systems and name countermeasures

Cryptography and IT-Security

Literature	- M. Howard, S. Lipner: "The Security Development Lifecycle", Microsoft Press, 2006 - Shostack: "Threat Modeling: Designing for Security", Wiley, 2014 - Paar, J. Pelzl: "Understanding Cryptography: A Textbook for Students and Practitioners", Springer, 2010 - Ristic: "Bulletproof SSL and TLS", Feisty Duck, 2015 - P. Engebretson: "The Basics of Hacking and Penetration Testing", Elsevier, 2011 - A. J. Menezes, P. C. van Oorschot, S. A. Vanstone:"Handbook of Applied Cryptography", CRC Press, 2001 - G. Schell, B. Wiedemann (Ed.): „Bussysteme in der Automatisierungs- und Prozesstechnik``. Springer, 2019 - R.C.Detmer: „Introduction to 80×86 Assembly Language and Computer Architecture``, Jones & Bartlett Learning, 2014. - D.L.Russel, P.C.Arlow: ``Industrial security : managing security in the 21st century", Wiley, 2015

Advanced Control Theory with Project

ID	ACT.P
Study section	Catalogue II
Responsible lecturer	Prof. Dr. Florian Kerber
Mandatory/elective	Elective
Rotation	Summer term, annually
Duration	1 term
Course	Advanced Control Theory with Project
CP / SWS	7,5 CP, 6 SWS
Workload	Total 7,5 CP x 25 h = 187,5 h thereof attendance 70 h, self-study 117,5 h
Study/Examination Performance	according to Syllabus and Examination Regulations and Record of Examinations Schedule
Marking	according §20 APO in its relevant version
Prerequisites	none
Applicability	Module to obtain essential credit points
Teaching language	English
Teaching/Learning method	Seminar-like lecture, exercise, lab tutorial
Contents	- Modelling and simulation of dynamical systems: differential equations, state space models, transfer functions. - Properties of dynamical systems: stability, controllability, observability, dissipativity. - State space control for linear systems: feedback control methods, in particular pole placement and optimal LQR control - Digital control systems: transform, analysis and system properties, controller cesign - Design of control systems with MATLAB and Simulink: real time systems, rapid control prototyping (lab tutorial) - mini projects

Advanced Control Theory with Project

Module objectives	**Learning outcomes** - Perceive the behaviour and determine properties of complex dynamical control systems. - Have a thorough acquaintance with modern feedback control strategies and techniques. - Employ effectively modern control design methodologies and tools for the design and implementation of feedback controllers. **Knowledge Targets** - Design control systems to meet a particular specification. - Analyse complex dynamical systems; detect problems and find solutions. - Design and test feedback control systems. **Capabilities** - Handle complex systems beyond the comprehension of one single human being through communication, control and teamwork. - Perform effectively within a group in the conduct of a practical control design project. - Know the benefits and limitations of modern control techniques for solving practical engineering tasks

Advanced Control Theory with Project

Literature	- Åström,. K. J.; Murray, R.: Feedback Systems: An Introduction for Scientists and Engineers Princeton University Press 2021 - van der Schaft, A; Jeltsema, D.: Port-Hamiltonian Systems Theory: An Introductory Overview 2014 - Dorf, R. C.; Bishop, R. H.: Modern Control Systems, Addison-Wesley 2010 - Franklin, G. F. ; Powell, J. D.; Emami-Naeini A.: Feedback Control of Dynamic Systems. Addison-Wesley, 2010 - Friedland, B.: Control System Design - An Introduction to State-Space Methods, McGraw-Hill 2005 - Messner, W C & D. M. Tilbury: Control Tutorials for MATLAB and Simulink: A Web-Based Approach, Addison-Wesley 1998 - Tewari, A: Modern Control Design: with MATLAB and Simulink, John Wiley & Sons 2002

Automation with Project

ID	AUT.P
Study section	Catalogue II
Responsible lecturer	Prof. Dr. Peter Kopystynski
Mandatory/elective	Elective
Rotation	Summer term, annually
Duration	1 term
Course	Automation with Project
CP / SWS	7,5 CP, 6 SWS
Workload	Total 7,5 CP x 25 h = 187,5 h thereof attendance 70 h, self-study 117,5 h
Study/Examination Performance	according to Syllabus and Examination Regulations and Record of Examinations Schedule
Marking	according §20 APO in its relevant version
Prerequisites	none
Applicability	Module to obtain essential credit points
Teaching language	English
Teaching/Learning method	Seminar-like lecture, exercise

Automation with Project

Contents	- Petri Net basics, timed models, application in programming tools for programmable controllers. - Introduction to stochastic systems, discrete- and continuous-time Markov chains. - Review of the programming concept for PLCs according to the norm IEC 61131-3. - Connectivity between SoftPLCs, Input/Output devices and commercial applications, e.g. visualisation based on OPC or industrial ethernet. - Design and verification of safety related programmable control systems according to European standards. - Modelling of nonlinear characteristics of temperature, magnetic, optic and chemical sensors. - Modelling of dynamic effects and limitations of sensors, e.g. cut-off frequency and parasitic elements - mini projects

Automation with Project

Module objectives	**Learning outcomes** - Become familiar with discrete event systems as the basis for modelling automation problems. - Be able to treat random effects in automation problems. - Perceive the principles of PLC networks. - Understand the principles and limitations of sensors and sensor systems. **Knowledge Targets** - Use simulation software to analyse the behaviour of a discrete event system. - Use PLC programming tools based on a graphical description of a discrete event system. - Configure a network of Programmable Logic Controllers connected via fieldbus and /or Ethernet. - Develop controller software according to the rules of IEC 61131-3. - Simulate sensors and circuits (e.g. with PSPICE or LabView) - Analyze data sheets & select appropriate components for automation & control systems **Capabilities** - Appreciate the value of formal description methods as the basis for problem solving. - Know the benefits and limitations of simulation as an engineering tool. - Perform effectively within a group in the conduct of a practical project.

Automation with Project

Literature	- Cassandras, Lafortune: Introduction to Discrete Event Systems, Kluwer Academic Press 1999 - David, Alla: Discrete, Continuous and Hybrid Petri Nets, Springer 2005 - Tornambe: Discrete-Event System Theory, World Scientific 1995 - John, Tiegelkamp: IEC 61131-3: Programming Industrial Automation Systems, Springer 2010 - Iwanitz, Lange, Burke: OPC : From Data Access to Implementation and Application, Hüthig 2010 - Hauke, et al.: Functional safety of machine controls -- Application of EN ISO 13849, DGUV 2009 - Fitzpatrick: Analogue Design and Simulation Using Orcad Capture and Pspice, Newnes 2011 - Bishop: LabVIEW 2009 Student Edition, Prentice Hall 2009

Electric Power Systems with Project	
ID	EPS.P
Study section	Catalogue II
Responsible lecturer	Prof. Dr. Michael Finkel
Mandatory/elective	Elective
Rotation	Summer term, annually
Duration	1 term
Course	Electric Power Systems with Project
CP / SWS	7,5 CP, 6 SWS
Workload	Total 7,5 CP x 25 h = 187,5 h thereof attendance 70 h, self-study 117,5 h
Study/Examination Performance	according to Syllabus and Examination Regulations and Record of Examinations Schedule
Marking	according §20 APO in its relevant version
Prerequisites	Detailed knowledge in basic structure of electric power supply systems and network components such as substations, cable, overhead lines and circuit breakers
Applicability	Module to obtain essential credit points
Teaching language	English
Teaching/Learning method	Seminar-like lecture, exercise

Electric Power Systems with Project

Contents	- Network components
	  - Transformers
	  - Operational behaviour of Power Lines
	  - Reactive Power Compensation in High Voltage Grids
	  - High Voltage DC transmission
	- Transmission and distribution system planning
	  - Load-flow, methods of network calculation
	  - Network protection
	- Network operation
	  - Monitoring and control
	  - Introduction to power system stability
	- Energy Storage Systems
	- Introduction to power system economics
	  - Current regulatory framework
	  - Energy markets
	  - Electricity tariffs
	- Smart Grids
	  - Impact of renewable generation on networks
	  - Smart generation
	  - Smart consumption
	  - Smart distribution grids
	  - Examples
	- mini projects

Electric Power Systems with Project

Module objectives	**Learning outcomes** - Understand the basis of operation of modern electrical power systems. - Be able to calculate effects in electrical power systems. - Perceive the principles of innovative solutions in electricity supply. - Know the components required for sustainable electricity supply systems. **Knowledge Targets** - Analyse energy transmission and distribution problems and identify appropriate solution methods. - Devise solutions for energy supply problems using state-of-the-art technologies. - Evaluate electricity networks - Adapt basic planning approaches to electricity systems. **Capabilities** - Demonstrate informed decision making skills whilst considering a range of impacts in supply systems. - Identify problems, produce and appraise solutions to network operational problems. - Use simulation software to configure power systems. - Appreciate the value of formal description methods as the basis for problem solving. - Know the benefits and limitations of simulation as an engineering tool. - Perform effectively within a group in a practical project.

Electric Power Systems with Project

Literature	- ABB, Switchgear Manual, 11th edition, ABB, 2006. - P. Kundur, Power System Stability and Control, McGraw-Hill, 1994, ISBN 0-07-035958-X. - K. Bhattacharya, M. H. J. Bollen and J. E. Daalder, Operation of restructured power systems, Kluwer Academic Publishers, USA, 2001. - Hensing, I.; Pfaffenberger, W.; Ströbele, W.: ``Energiewirtschaft``, Vahlen Verlag (ISBN 3-486-24315-2) - Bernd M. Buchholz, Zbigniew Styczynski, Smart Grids -- Fundamentals and Technologies in Electricity Networks, Springer 2014 - C. Rehtanz, Monitoring, Control and Protection of Interconnected Power Systems, Springer 2014 - CIGRE, technical brochure 475: Demand side integration, 2011 - In addition to many selected published papers in IEEE.

Selected Topics on Digital Communications with Project	
ID	DC.P
Study section	Catalogue II
Responsible lecturer	Prof. Dr. Matthias Kamuf
Mandatory/elective	Elective
Rotation	Summer term, annually
Duration	1 term
Course	Selected Topics on Digital Communications with Project
CP / SWS	7,5 CP, 6 SWS
Workload	Total 7,5 CP x 25 h = 187,5 h thereof attendance 70 h, self-study 117,5 h
Study/Examination Performance	according to Syllabus and Examination Regulations and Record of Examinations Schedule
Marking	according §20 APO in its relevant version
Prerequisites	Basic course on Signals and Systems
Applicability	Module to obtain essential credit points
Teaching language	English
Teaching/Learning method	Seminar-like lecture, practical exercise
Contents	*Modulation* e.g. transmission in lowpass vs. bandpass regime, single- vs. multi-carrier transmission, MIMO transmission modes *Signal processing algorithms* e.g. automatic gain control; receiver synchronisation; adaptive and non-adaptive digital filters and their application in channel estimation, equalisation, oversampling, resampling etc. *Implementations* FPGA implementations; transceiver architectures; quantisation *mini projects*

Selected Topics on Digital Communications with Project

Module objectives	**Learning outcomes** - Understand the functionality and the limitation of modern algorithms and protocols for communication systems - Have a thorough acquaintance with writing and testing algorithms and protocols and also how to integrate them in an existing signal processing architecture - Develop simulation models of communication systems and their signal processing algorithms for simulation in frequency domain, time domain, floating point and fixed-point. - Develop implementations of signal processing algorithms on a programmable hardware platform. - Be aware of hardware limitations imposed on signal processing algorithms and find implementation choices which take these into account. **Knowledge Targets** - Read and comprehend technical specifications and block diagrams of communication systems. - Model, design, simulate, optimise, test and implement communication systems and their signal processing algorithms. - Critically evaluate choices of implementation of communication systems and their algorithms with regard to design effort, hardware effort, power consumption, and overall system cost. **Capabilities** - Use the available range of high-level languages for algorithm modeling, simulation and implementation of communication systems and their building blocks. - Improve oral and written communication skills. - Work effectively in a team. - Be able to think and work on different levels of abstraction.

Selected Topics on Digital Communications with Project	
Literature	- Rimoldi: Principles of Digital Communication, Cambridge, 2016 - Heath: Introduction to Wireless Digital Communication, Prentice Hall, 2017 - Haykin: Adaptive Filter Theory, Prentice Hall, 2001 - Tanenbaum et al.: Computer Networks, Prentice Hall, 2020

VLSI-Design with Project

ID	VLSI.P
Study section	Catalogue II
Responsible lecturer	Prof. Dr. Friedrich Beckmann
Mandatory/elective	Elective
Rotation	Summer term, annually
Duration	1 term
Course	VLSI-Design with Project
CP / SWS	7,5 CP, 6 SWS
Workload	Total 7,5 CP x 25 h = 187,5 h thereof attendance 70 h, self-study 117,5 h
Study/Examination Performance	according to Syllabus and Examination Regulations and Record of Examinations Schedule
Marking	according §20 APO in its relevant version
Prerequisites	none
Applicability	Module to obtain essential credit points
Teaching language	English
Teaching/Learning method	Seminar-like lecture, exercise

VLSI-Design with Project

Contents	- Design Styles: Full custom design; standard cell approach; hardware and behaviour description entry approach; functional abstraction; rules and hints on decision-making. - Design Flow: Function entry; verification; timing analysis; synthesis layout; - Hierarchical Design Styles: Cells; blocks; buses; high-level hardware description language (HDL). - Hardware Description Language Entry: Behavioural, structural and functional function entry using VHDL. - CAD Tools: Compilation; simulation; synthesis; static timing analysis; routing. placement.; - Guide to verifying complex systems. Introduction to Testing: Manual and automatic test pattern generation. Design for Testability: rules; procedures; methods. - Management Issues: Splitting designs into blocks; releases and release management; bug tracking; design rules. - mini projects

VLSI-Design with Project

Module objectives	**Learning outcomes** - Become familiar with the design styles and the rules for current implementation approaches. - Write behavioural and structural code in a hardware description language according to a specification in natural language. - Handle complex hierarchical structures - Be aware of the limitations of functional verification and specify verification patterns. - Have a thorough acquaintance with the r oles of automatic testing and design for testability. **Knowledge Targets** - Read and comprehend technical specifications. - Design, code, simulate, synthesise and implement complex digital functions and systems. - Critically evaluate verification approaches, be aware of the limitations and risks, especially in life supporting systems. - Use the available range of CAD tools for HDL input, simulation, verification, synthesis, static timing analysis and layout. **Capabilities** - Recognise the inherent ambiguity of natural language in contrast to formal language - Handle complex systems beyond the comprehension of one single human being through abstraction, communication and teamwork - Appreciate the difference between functional verification, formal verification and falsification as well as the limitations in proving the correctness of theories and finding truth through simulation or testing.

VLSI-Design with Project	
Literature	- A. Eder: VHDL Short Course & Guide to Synthezisable Code, FHA Intranet 2005 - Barry Wilkinson: The Essence of Digital Design, Prentice Hall Europe 1998 - Ashenden: The Designer' s Guide to VHDL, Morgan Kaufman 2001 - William K. Lam: Hardware Design Verification: Simulation and Formal Method Based Approaches, Prentice Hall 2005

Emerging Technologies

ID	EMT
Study section	Technical required elective modules
Responsible lecturer	Prof Dr Matthias Kamuf
Mandatory/elective	Elective
Rotation	Winter semester, annually
Duration	1 semester
Course	Emerging Technologies
CP / SWS	5 CP, 4 CREDIT HOURS
Workload	Total workload 5 CP x 25 h = 125 h of which attendance time 47 h, self-study 78 h
Study/Examination Performance	according to SPO and curriculum
Marking	according to §20 of the APO in the currently valid version
Prerequisites	none
Applicability	Required elective module to obtain the necessary credit points according to the SPO
Teaching language	German, English
Teaching/Learning method	Seminar-based teaching, exercise course
Contents	Each semester, this seminar highlights one to a maximum of two current, research-related topics, e.g. the latest developments in AI, smart mobility or sustainability, which are presented as part of a lecture series. (Guest) lecturers from the respective research areas provide a basic introduction to the topic.

Emerging Technologies

Module objectives	By writing a paper based on the content of the individual lectures and deepening the topics covered there, students learn to critically analyse the content already taught by independently researching further detailed information and preparing it scientifically. In a colloquium, the content of the dissertation is then communicated and debated. To this end, it is essential that students carefully work through the contributions of their fellow students in advance.
Literature	Abhängig vom jeweiligen Themenschwerpunkt

Energy Management and System Operation	
ID	EWSYS
Study section	Technical required elective modules
Responsible lecturer	Prof Dr Michael Finkel
Mandatory/elective	Elective
Rotation	Winter semester, annually
Duration	1 semester
Course	Energy Management and System Operation
CP / SWS	5 CP, 4 CREDIT HOURS
Workload	Total workload 5 CP x 25 h = 125 h of which attendance time 47 h, self-study 78 h
Study/Examination Performance	according to SPO and curriculum
Marking	according to §20 of the APO in the currently valid version
Prerequisites	none
Applicability	In-depth required elective module to obtain the necessary credit points according to the SPO
Teaching lan-guage	German
Teaching/Learning method	Seminar-based teaching, practical experiments

Energy Management and System Operation	
Contents	Electrical power systems are among the most important assets and are responsible for the secure and uninterrupted supply of electricity to a country. This module provides an overview of the energy engineering tools required to ensure that the electricity supply exactly matches the electricity demand at all times and that system stability is guaranteed so that any unforeseen change or disturbance in the system does not lead to a partial or complete interruption of supply. Energy industry - Introduction - Incentive regulation and grid charges - From congestion management to redispatch - Balancing group management - Flexibilities in the distribution grid - Grid connection rules Stability and control of electrical energy systems - Definition of system stability - Rotor angle, frequency and voltage stability - Effects of inverter-based generation on system stability - Frequency/active power control - Voltage/reactive power control - In-depth study of selected topics in practical experiments accompanying the lecture

Energy Management and System Operation	
Module objectives	**Knowledge** - Students can describe the business processes along the entire energy industry value chain (generation, distribution and transport, trading, sales) and know the most important energy industry processes (liberalization of the markets, regulation, unbundling, etc.) in the company and their implementation. - Students know the factors influencing the system stability of electricity supply systems and are familiar with the control concepts used in the various areas. **Skills** - Students will be able to recognize and critically question interrelationships in the energy markets. - Students are able to understand the interdisciplinary characteristics of energy markets, including legal/regulatory, economic, ecological and technical determinants. - Students know how to ensure the stable operation of the electrical energy supply system. **Competences** - Students are enabled to view and understand the energy market with its market roles and perspectives (legal, technical, economic) in a differentiated manner. The selected teaching and learning methods encourage students to engage in critical discussion. - Students will be able to evaluate aspects of the system stability of the electricity grid and the control technologies used in electricity grids in the context of the energy transition.

Energy Management and System Operation

EN$_Literatur$	- M. Finkel, Intended and Unintended Islanding of Distribution Grids, The Institution of Engineering and Technology (IET), 2024 - Hensing, I.; Pfaffenberger, W.; Ströbele, W.: ``Energiewirtschaft``, Vahlen Verlag (ISBN 3-486-24315-2) - P. Kundur, Power System Stability and Control, McGraw-Hill, 1994, ISBN 0-07-035958-X . - C. Rehtanz, Monitoring, Control and Protection of Interconnected Power Systems, Springer 2014 - ausgewählte Fachpublikationen

Design and Technologie of Electrical Machines	
ID	EEM
Study section	Technical required elective modules
Responsible lecturer	Prof Dr Wolfgang Meyer
Mandatory/elective	Elective
Rotation	Winter semester, annually
Duration	1 semester
Course	Design and technology of electrical machines
CP / SWS	5 CP, 4 CREDIT HOURS
Workload	Total workload 5 CP x 25 h = 125 h of which attendance time 47 h, self-study 78 h
Study/Examination Performance	according to SPO and curriculum
Marking	according to §20 of the APO in the currently valid version
Prerequisites	- Knowledge of the functionality and stationary operating behaviour of the following electrical machines: Synchronous machine, asynchronous machine and direct current machine (VO Drive Technology or Electrical Machines) - Fundamentals of complex alternating current theory (VO ET2)
Applicability	In-depth required elective module to obtain the necessary credit points according to the SPO
Teaching language	German
Teaching/Learning method	Seminar-based teaching, exercise course

Design and Technologie of Electrical Machines

Contents	- Fundamentals of the design of electrical machines - Determination and significance of the main dimensions - Winding laws, design and calculation of distributed and concentrated windings - Electromagnetic, thermal and mechanical design guidelines - Analytical and numerical calculation principles of direct current, synchronous and asynchronous machines - Magnetic networks - Properties of semi-finished products used in electrical machine construction (dynamo sheets, composite materials, insulation, permanent magnets) - Loss mechanisms in electrical machines (methods for recalculation, iron losses, copper losses, additional losses) - Cooling methods for electromechanical converters - Production steps and various manufacturing technologies for electrical machines with influence on efficiency. - Individual components of electromechanical converters (flux-carrying material, windings, housing, shaft, bearings, brushless apparatus, terminal box, fan) - DIN standards for the semi-finished products used in electrical engineering and for electromechanical converters. - Occurring fault patterns, maintenance and repair of electrical actuators

Design and Technologie of Electrical Machines	
Module objectives	**Knowledge:** - You know the mechanical structure and the individual parts of an electrical machine. - You will be familiar with electromagnetic, thermal and mechanical design guidelines - They know the basic design process for electromechanical converters - Students know the production steps of an electromechanical transformer and acquire technical language skills. - They are familiar with the typical fault patterns and know which maintenance and repair options are available for electromechanical converters. - Students are familiar with the various loss mechanisms (iron losses, copper losses, additional losses) in electrical machines and know which cooling methods are used technically. **Skills:** - Students are able to independently design an electrical machine. - Students are able to estimate the main dimensions of an electrical machine and design a corresponding winding diagram. - Students are able to dimension the magnetic circuit of electromechanical converters. - Students will be able to use the relevant standards to classify the individual components of a machine. **Competences:** - Students are able to assess a machine with regard to its design criteria and different recalculation methods for electromechanical converters. - They understand the material properties of the semi-finished products used in electrical machine construction and are able to assess their use in terms of efficiency. - Students will be able to assess the calculation methods used to determine the individual losses in connection with the design of the machine.

Design and Technologie of Electrical Machines

Literature	Folgende Literatur wird empfohlen: - W. Meyer, ``Automatisierter Entwurf elektromechanischer Wandler'', Hironymus München, 2009 - G. Jonas, ``Grundlagen zur Auslegung und Berechnung elektrischer Maschinen'', VDE Verlag, Berlin Offenbach, 2001 - R. Richter, ``Lehrbuch elektrischer Wicklungen'', G. Braunsche Hofdruckerrei und Verlag GmbH, Karlsruhe, 1952 - G. Müller, B. Ponick: Grundlagen elektrischer Maschinen: Elektrische Maschinen 1, 2005. - G. Müller, B. Ponick: Theorie elektrischer Maschinen, 2009. - G. Müller, K. Vogt, B. Ponick: Berechnung elektrischer Maschinen: Elektrische Maschinen 2, 2007. - R. Tzscheutschler: Technologie des Elektromaschinenbaus, 1990

IIoT and Robotics

ID	IIoTROB
Study section	Technical required elective modules
Responsible lecturer	Prof. Dr Christoph Zeuke
Mandatory/elective	Elective
Rotation	Winter semester, annually
Duration	1 semester
Course	IIoT and Robotics
CP / SWS	5 CP, 4 CREDIT HOURS
Workload	Total workload 5 CP x 25 h = 125 h of which attendance time 47 h, self-study 78 h
Study/Examination Performance	according to SPO and curriculum
Marking	according to §20 of the APO in the currently valid version
Prerequisites	Robot Systems Engineering, Embedded Systems I, Embedded Systems II
Applicability	In-depth required elective module to obtain the necessary credit points according to the SPO
Teaching language	German
Teaching/Learning method	Seminar-based teaching, internship / lab course

IIoT and Robotics

Contents	**Introduction to IIoT and robotics:** - Definitions, development history and current trends in the Industrial Internet of Things (IIoT) and robotics. - Delimitation of the fields of application and synergies between IIoT and robotics. **Sensor technologies for IIoT and robotics:** - Advanced sensor technologies: use and integration in industrial and robotic applications. - Sensor fusion and modern sensor models for precise data acquisition. **Communication technologies and protocols:** - Wireless and wired communication technologies for IIoT and robotics applications. - Use of efficient communication protocols for distributed systems. **Cloud infrastructures in IIoT and robotics:** - Fundamentals of cloud infrastructures and their importance in IIoT and robotics. - On-premises solutions and strategies for the integration of cloud services. **Data management and algorithms:** - Data quality, storage and analysis in IIoT and robotics applications. - Visualisation techniques and use of machine learning for intelligent data evaluation. - Static and dynamic modelling of control systems **Process control and automation:** - Concepts and applications of process control in the context of IIoT and robotics. - Control and automation of processes through the use of robotics and IIoT. - Real-time capable control systems

IIoT and Robotics	
Contents	**Laboratory projects and practical applications:** - Practical implementation of IIoT and robotics projects in the laboratory. - Application of simulation tools and hardware platforms. **Future prospects and challenges:** - Prospects for future developments in IIoT and robotics. - Discussion of ethical and social aspects, safety issues and challenges in research and industry. You will learn how the IIoT and robotics will affect current and future production, what opportunities and risks exist and, above all, how you can help shape it and implement your own projects. You will develop a fully automated production process, from collecting the necessary sensor data to controlling a robot cell, and optimise the production process using the latest methods and tools.

IIoT and Robotics	
Module objectives	**Knowledge:** - Students can reproduce technical terms and the structure of IIoT. - Applications as well as technological limits and risks can be named. - They know the procedure for developing and introducing an IIoT device and the roles of the people involved. - They are familiar with suitable methods for linking sensors and actuators. - They are familiar with the control-related functionalities of robotics. **Skills:** - Students can research the state of the art and familiarise themselves with new standards in the field of IIoT and robotics. - They are able to describe their own industrial applications in a suitable form and drive their realisation forward. - You will be able to record, process, transfer, appropriately evaluate and visualise data using an IIoT device. - You will be able to use the collected data specifically for control and process regulation. **Competences:** - Students can characterise and assess IoT and robotics solutions. - They can evaluate and propose new fields of application. - They are able to design necessary organisational structures and transfer existing processes in an appropriate way. - Students can analyse and assess complex tasks and summarise and defend their laboratory project in the form of a scientific publication.

IIoT and Robotics

Literature	- Vorlesungsskript, Versuchsanleitungen, Dokumentationen zu verwendeten Controllern, Sensoren, Frameworks ... - Weyrich, M.; Industrielle Automatisierungs- und Informationstechnik, IT-Architekturen, Kommunikation und Software zur Systemgestaltung; Springer-Verlag 2023 - Mareczek, J.; Grundlagen der Roboter-Manipulatoren - Band 2, Pfad- und Bahnplanung, Antriebsauslegung, Regelung ; Springer-Verlag 2020 - Mareczek, J.; Grundlagen der Roboter-Manipulatoren - Band 1, Modellbildung von Kinematik und Dynamik ; Springer-Verlag 2020 - Ergänzende aktuelle Fachliteratur

Power Electronics and Power Supply Design	
ID	LE
Study section	Technical required elective modules
Responsible lecturer	Prof Dr Matthias Ritter
Mandatory/elective	Elective
Rotation	Winter semester, annually
Duration	1 semester
Course	Power electronics and power supply technology
CP / SWS	5 CP, 4 CREDIT HOURS
Workload	Total workload 5 CP x 25 h = 125 h of which attendance time 47 h, self-study 78 h
Study/Examination Performance	according to SPO and curriculum
Marking	according to §20 of the APO in the currently valid version
Prerequisites	Basic mathematical and electrotechnical knowledge
Applicability	In-depth required elective module to obtain the necessary credit points according to the SPO
Teaching language	German
Teaching/Learning method	Seminar-based teaching, exercise course
Contents	- Basic circuits of DC/DC power supply technology - Resonant and soft-switching DC/DC converters - Design and control of single-phase and multi-phase inverters - Fundamentals of modern power semiconductors - Switching behaviour of power semiconductors - EMC-compliant circuit board layout in DC/DC converters - Dimensioning of passive components in power electronics - Methods for controlling power semiconductors - Internal measurement systems in power electronics - Simulation of power electronic circuits

Power Electronics and Power Supply Design	
Module objectives	**Knowledge:** - You know the structure and functionality of various DC/DC converter topologies - You know the basic design process for DC/DC converter topologies - You will be familiar with various topologies and control methods for inverters - You will be familiar with the various loss mechanisms in active and passive components and know which cooling methods are technically applicable. - You know the typical error patterns in power electronics and can determine possible causes **Skills:** - You will be able to independently dimension the active and passive components of power electronic circuits. - You will be able to draw up a thermal equivalent circuit diagram for power electronic components. - You will be able to select a suitable driver circuit for power semiconductors **Competences:** - You will be able to assess different DC/DC topologies with regard to their design criteria - You will be able to assess the influence of placement and layout on the electromagnetic compatibility of power electronic circuits - You will be able to apply sustainability aspects when selecting components for power electronic circuits
Literature	- R. W. Erickson and D. Maksimović, Fundamentals of Power Electronics. Springer Nature, 2020. - U. Schlienz, Schaltnetzteile und ihre Peripherie. 2020. doi: 10.1007/978-3-658-29490-8. - A. Wintrich, U. Nicolai, W. Tursky, T. Reimann, Applikationshandbuch Leistungshalbleiter. ISLE Verlag, 2015, ISBN 978-3-938843-85-7

Safety	
ID	IS2S3
Study section	Technical required elective modules
Responsible lecturer	Prof Dr Wolfgang Zeller
Mandatory/elective	Elective
Rotation	Winter semester, annually
Duration	1 semester
Course	Safety
CP / SWS	5 CP, 4 CREDIT HOURS
Workload	Total workload 5 CP x 25 h = 125 h of which attendance time 47 h, self-study 78 h
Study/Examination Performance	according to SPO and curriculum
Marking	according to §20 of the APO in the currently valid version
Prerequisites	Introduction to Safety, Security and Human Machine Interaction
Applicability	Module for obtaining the necessary credit points according to SPO
Teaching language	German
Teaching/Learning method	Seminar-based teaching

Safety

Contents	**Introduction** - Examples of use, current significance, objectives **Mathematical basics** - Random events and probability theory - Failure behaviour of technical systems and distribution functions - Markov modelling **Methods of risk analysis and assessment** - FMEA and FMEDA - Fault trees **Safety-relevant system architectures and their calculation** - Single and multi-channel systems - Calculation of characteristic variables to describe the probability of failure and diagnostic coverage **Methods for avoiding common cause failures** - Technical and organisational measures - Included in the calculation of the failure behaviour **Development of safety-relevant control software** - Basic procedures for avoiding systematic faults - Input into the methodical development and proof of safety-relevant control systems **Methods of verification and validation** - Fundamentals of testing and proof of the properties of safety-relevant control systems - Computer-aided methods **Exemplary application of mathematical and methodological principles** - Production machines (operating modes) - Industrial robots (human-machine collaboration) - Automotive engineering (autonomous driving)

Safety

Module objectives	**Knowledge:** - Students know the mathematical and theoretical principles of probability calculation and the failure behaviour of technical systems. - They can outline the methodical procedure for designing safety functions using relevant basic standards. **Skills:** - Students are able to mathematically prove the functional safety of control systems in accordance with legal and normative requirements. - Building on this, students are able to apply procedures for the methodical approach and proof of the properties of safety-relevant systems in a targeted manner. **Competences:** - Students acquire the ability to successfully transfer their basic knowledge to industry-specific issues based on practical use cases from different areas. - They are able to independently assess the functional safety of control systems from a technical and economic point of view.

Safety

Literature	- Vortragsfolien, Begleit- und Übungsmaterial in moodle - Goble, W.: Control Systems Safety Evaluation and Reliabilty, Instrument Society of America, 2010, ASIN: B017R2U3LO - Börcsök, Josef: Funktionale Sicherheit - Grundzüge sicherheitstechnischer Systeme, 5. überarb. Aufl., VDE Verlag, Berlin, 2021. ISBN 978-3800753574 - Smith, David u. Simpson, Kenneth G. L.: Safety Critical Systems Handbook - A Straightfoward Guide to Functional Safety, IEC 61508 and Related Standards, 3rd edition, Elsevier, 2010. ISBN 978-0080967813 - IEC 61508: Funktionale Sicherheit sicherheitsbezogener elektrischer / elektronischer / programmierbarer elektronischer Systeme, Teil 1 bis 7, Beuth 2011.

Secure Implementation on Microcontrollers

ID	IS2S5
Study section	Technical required elective modules
Responsible lecturer	Prof Dr Helia Hollmann
Mandatory/elective	Elective
Rotation	Summer semester, annually
Duration	1 semester
Course	Secure implementation on microcontrollers
CP / SWS	5 CP, 4 CREDIT HOURS
Workload	Total workload 5 CP x 25 h = 125 h of which attendance time 47 h, self-study 78 h
Study/Examination Performance	according to SPO and curriculum
Marking	according to §20 of the APO in the currently valid version
Prerequisites	none
Applicability	Module for obtaining the necessary credit points according to SPO
Teaching lan-guage	German
Teaching/Learning method	Seminar-based teaching, internship / lab course
Contents	1. cryptographic basics (hash, symmetric and asymmetric cryptographic algorithms) 2. invasive and non-invasive attacks on microcontrollers 3. techniques to secure microcontrollers against attacks 4. C implementations on microcontrollers 5. development of secure software

Secure Implementation on Microcontrollers

Module objectives	Protecting embedded systems against attacks by third parties on stored data and implementations is an increasingly important task, but also a challenging one due to increasing networking. This lecture aims to provide in-depth knowledge of possible attacks on microcontrollers and to examine the possibilities of protecting microcontrollers using software implementations. In practical exercise courses, this knowledge will be implemented independently in small groups and attacks can be carried out using the ChipWhisperer® provided in order to put implemented countermeasures to the test.

Secure Implementation on Microcontrollers

Literature	- Mangard, S., Oswald, E., Popp, T. (2007). Power Analysis Attacks: Revealing the Secrets of Smart Cards. Niederlande: Springer US. - Woudenberg, J. v., O'Flynn, C. (2021). The Hardware Hacking Handbook: Breaking Embedded Security with Hardware Attacks. USA: No Starch Press. - Kocher, P., Jaffe, J., Jun, B. (1999). Differential Power Analysis. In: Wiener, M. (eds) Advances in Cryptology --- CRYPTO' 99. CRYPTO 1999. Lecture Notes in Computer Science, vol 1666. Springer, Berlin, Heidelberg. https://doi.org/10.1007/3-540-48405-1_25 - Kocher, P., Jaffe, J., Jun, B. et al. Introduction to differential power analysis. J Cryptogr Eng 1, 5--27 (2011). https://doi.org/10.1007/s13389-011-0006-y - E. Brier, C. Clavier, and F. Olivier. Correlation Power Analysis with a Leakage Model. In M. Joye and J.-J. Quisquater, editors, Cryptographic Hardware and Embedded Systems -- CHES 2004, volume 3156 of Lecture Notes in Computer Science, pages 16--29. Springer, 2004 - Mangard, S., Oswald, E., Popp, T., „Power Analysis Attacks: Revealing the Secrets of Smart Cards``, Niederlande: Springer US, 2007. - Woudenberg, J. v., O'Flynn, C, „The Hardware Hacking Handbook: Breaking Embedded Security with Hardware Attacks``, USA: No Starch Press, 2021. - Kocher, P., Jaffe, J., Jun, B., „Differential Power Analysis``, in: Wiener, M. (eds) Advances in Cryptology --- CRYPTO' 99. CRYPTO 1999, Lecture Notes in Computer Science, vol 1666. Springer, Berlin, Heidelberg, https://doi.org/10.1007/3-540-48405-1_25 - E. Brier, C. Clavier, and F. Olivier, „Correlation Power Analysis with a Leakage Model``, in M. Joye and J.-J. Quisquater, editors, Cryptographic Hardware and Embedded Systems - CHES 2004, volume 3156 of Lecture Notes in Computer Science, pages 16--29. Springer, 2004

Product Development and Management	
ID	PM
Study section	Interdisciplinary specialisation
Responsible lecturer	Prof Dr Martina Königbauer
Mandatory/elective	Elective
Rotation	Winter semester, annually
Duration	1 semester
Course	Development methodology
CP / SWS	5 CP, 4 CREDIT HOURS
Workload	Total workload 5 CP x 25 h = 125 h of which attendance time 45 h, self-study 80 h
Study/Examination Performance	according to SPO and list of course assessments
Marking	according to §20 of the APO in the currently valid version
Prerequisites	none
Applicability	Required elective module to obtain the necessary credit points according to the SPO
Teaching language	German
Teaching/Learning method	Seminar-based teaching, exercise course
Contents	Students learn planning and management methods for product development and management. In doing so, they deal with the prerequisites that must be met for their use and the consequences that result from them. They also deal with the connection between these methods and concepts in the context of a product development process. Topics: - Approaches to product development - Management by approaches - Design for approaches - Prototyping methods - Key decisions of the disciplines involved in product development, e.g. product management, innovation management, quality management, sales, purchasing, project management, sustainability management, etc.) - Key interfaces and problems between the disciplines involved in product development Exercise courses are worked on individually and in teams.

Product Development and Management	
Module objectives	**Knowledge:** - Students know different approaches to product development as well as their advantages and disadvantages in different contexts - Students know the main influences and decisions that are relevant in different phases of the product development process. **Skills:** - Students can identify and apply appropriate management and leadership techniques depending on the context. - Students can independently prepare decisions in product development and product management. **Competences:** - Students can assess the influence of the above-mentioned management areas on product development and management. - Students can design and visualise a systematic product development process for an example product.
Literature	- Lindemann, U.; Handbuch Produktentwicklung, Carl Hanser Verlag, München 2016 - Lindemann, U.; Handbuch Produktentwicklung, Carl Hanser Verlag, München 2016 - Lemser, F.: Strategisches Produktmanagement, Books on Demand; 2. Edition (2018) - Lippold, D.:Die 75 wichtigsten Management- und Beratungstools: Von der BCG-Matrix zu den agilen Tools, De Gruyter Oldenbourg; 1. Edition (2020) - Folien mit Verweisen auf Webseiten

Research Methods	
ID	RM
Study section	Interdisciplinary specialisation
Responsible lecturer	Prof Dr Wolfgang Zeller
Mandatory/elective	Elective
Rotation	Winter semester, annually
Duration	1 semester
Course	Research Methods
CP / SWS	5 CP, 4 CREDIT HOURS
Workload	Total workload 5 CP x 25 h = 125 h of which attendance time 45 h, self-study 80 h
Study/Examination Performance	according to SPO and list of course assessments
Marking	according to §20 of the APO in the currently valid version
Prerequisites	none
Applicability	Required elective module to obtain the necessary credit points according to the SPO
Teaching language	German / English
Teaching/Learning method	Seminar-based teaching, exercise course
Contents	The ``Research Methods'' module teaches basic and advanced qualitative and quantitative methods of scientific work with particular reference to research activities, e.g. various research designs, data collection methods and statistical analysis procedures. Ethical aspects of research and principles of scientific integrity are also addressed. Another focus is on the application of standards in a technical context. Exercise courses are worked on individually and in teams.

Research Methods

Module objectives	**Knowledge:** - Students know different methods of scientific work. - Students know the standards relevant to their research. - Students know relevant ethical principles. **Skills:** - Students can apply different methods of scientific work. - Students can identify and apply appropriate standards depending on the context. - Students can make and justify ethical decisions. **Competences:** - Students are able to plan their own research projects, select suitable methods, collect and analyse data using modern analysis tools and present and interpret research results in a well-founded manner.
Literature	Wird im Unterricht bekanntgegeben.

Master Modules

EN$_{B}ESCHREIBUNG$	Further modules totalling a maximum of 10 CP can be selected from the university-wide range of Master's courses. Specific information can be found in the module handbooks of the respective faculty.

Master Project 1	
ID	MP1
Study section	Projects
Responsible lecturer	Prof Dr Alexander Frey
Mandatory/elective	Elective
Rotation	Winter and summer semester
Duration	1 semester
Course	Project 1
CP / SWS	10 CP
Workload	Total workload 10 CP x 25 h = 250 h The scope can be reduced to 5 CP by participating in mini-projects of other modules. of which attendance time 30 h, self-study (here: practical realisation of a project) 220 h
Study/Examination Performance	according to SPO and curriculum
Marking	according to §20 of the APO in the currently valid version
Prerequisites	none
Applicability	Module for obtaining the necessary credit points according to SPO
Teaching language	German/English
Teaching/Learning method	Project work, accompanied by seminar-based teaching

Master Project 1	
Contents	The Master Project 1 module is designed to provide students with practical insights into the fields of simulation and modelling. Through the concrete implementation of a real project, students should not only deepen their theoretical knowledge in the field of modelling and simulation of complex technical systems, but also develop practical skills in project management, resource planning and cost calculation. By working in small groups, the students' teamwork and communication skills are promoted. This module is supported by accompanying lectures and seminar-style teaching to help students develop their project management skills and deepen their knowledge of simulation and modelling.

Master Project 1	
Module objectives	**Knowledge:** - Students can use simulation and modelling terminology with confidence. - Applications as well as limitations and risks can be named. - They know the procedure for developing a model for a complex technical system and know how to interpret the simulation results. - Students know how to prepare and present the information obtained. **Skills:** - Students can research the state of the art and familiarise themselves with new standards in the field of modelling and simulation. - They are able to describe their own applications in a suitable form and realise them. - They can draw up a realistic project plan and implement the project in accordance with it. - They can model complex technical systems with modern tools and carry out simulations. - Students can interpret, prepare and present the simulation results. - Students can familiarise themselves with a new subject area within a short period of time and apply the state of the art. **Competences:** - Students can model technical systems and carry out suitable simulations. - They can identify relevant points and react to a dynamic project process. - They can organise themselves in a team and divide tasks equally and in a competence-oriented manner. - Students can maintain a respectful and solution-orientated approach in a team. - They can resolve conflicts within the team themselves or seek suitable external help if necessary. - Students can summarise and defend their project in the form of a scientific publication. - Students can present, discuss and defend the progress of their project and the technical content in front of lecturers.

Master Project 1

Literature	- Vorlesungsskript - Ergänzende aktuelle Fachliteratur

Master Project 2	
ID	MP2
Study section	Projects
Responsible lecturer	Prof Dr Christine Schwaegerl
Mandatory/elective	Elective
Rotation	Winter and summer semester
Duration	1 semester
Course	Project 2
CP / SWS	5 CP
Workload	Total workload 5 CP x 25 h = 125 h of which attendance time 15 h, self-study (here: practical realisation of a project) 110 h
Study/Examination Performance	according to SPO and curriculum
Marking	according to §20 of the APO in the currently valid version
Prerequisites	none
Applicability	Module for obtaining the necessary credit points according to SPO
Teaching language	German
Teaching/Learning method	Project work, accompanied by seminar-based teaching
Contents	As part of a small research project, the current state of the art is to be developed and presented. On this basis, a specific research topic will be investigated and advanced in a data-illustrated manner. Special attention will be paid to test planning and validation, to ensure the robustness and reliability of the results. The results obtained are presented and discussed in detail in a scientific publication. You will have the opportunity to put into practice the theory and scientific methods taught through accompanying impulse lectures and self-study. This project thus lays the foundation for a successful master's thesis.

Master Project 2

Module objectives	**Knowledge:** - In-depth knowledge of the current state of the art in the relevant field of research. - Understanding of the planning and implementation of research projects, taking into account experimental design and validation. - Ability to critically record, present and discuss research results in scientific publications. - Practical application of scientific methods within the framework of the research project. **Skills:** - Application of experimental design and validation techniques to ensure the robustness and reliability of research results. - Realisation of a detailed investigation and further development of a specific research topic. - Practical testing and application of scientific methods within the research project. - Preparation and writing of a scientific publication. **Competences:** - Ability to conduct independent research and specialisation in relevant scientific topics. - Ability to work in a team and collaborate in a small research project. - Critical thinking and analytical skills for comprehensive assessment of research results. - Professional communication of research findings in written form and oral discussions. - Preparing and building a solid foundation for the successful realisation of a master's thesis.
Literature	- Vorlesungsskript - Ergänzende aktuelle Fachliteratur

Master Thesis	
ID	MA
Study section	master's thesis
Responsible lecturer	Professors of the faculty(ies) involved in the degree program
Mandatory/elective	Compulsory
Rotation	Semester cycle
Duration	6 months
CP / SWS	30 CP
Workload	Total workload 30 CP x 25 h = 750 h
Study/Examination Performance	according to SPO and curriculum
Marking	according to §20 of the APO in the currently valid version
Prerequisites	according to §9 of the SPO
Teaching language	German or English (see SPO)
Contents	Each student is assigned an individual topic for their master's thesis. It can be worked on in the laboratories of Augsburg University of Applied Sciences, as part of research projects or in cooperation with companies or research institutions. Each student is supervised by a suitable supervisor with examination authorisation.
Module objectives	The master's thesis is proof of the ability to work independently on a technical problem or assignment using engineering methods within a specified deadline.
Literature	Fachliteratur gemäß dem individuellen Thema der Masterarbeit