SuSe
2020

HOCHSCHULE COBURG

Module Manual

FOR THE BACHELOR'S DEGREE IN AUTOMATION TECHNOLOGY AND ROBOTICS (AU)

DEPARTMENT OF ELECTRICAL ENGINEERING AND COMPUTER SCIENCE

As of 3/4/2020 – Valid for SuSe 2020 – SPO from 2017 - Subject to change!

Study plan for the bachelor's degree program **Automation Technology and Robotics**

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Notes: The numbers above the course overview indicate the number of ECTS credit points. There is a total of 210 ECTS points.
The number of Semester Week Hours = SWH is indicated in the syllabus.

Preliminary remarks

One ECTS credit point according to the "European Credit and Accumulation Transfer System" corresponds to a workload of 30 hours per semester.

The explanation of the formal admission requirements for the individual modules can be found in the Study and Examination Regulations (SPO) of the academic program.

Please note:
The module handbook lists all modules for which examinations are offered in the respective semester, but they do not necessarily have to be taught in this semester.

Compulsory elective modules:
According to the curriculum, subject-specific compulsory and compulsory elective modules can also be taken as subject-specific compulsory elective modules, which are offered for the academic programs Electrical Engineering and Information Technology (EL), Power Engineering and Renewable Energies (EN) and Computer Science (IF).

Risk assessment according to §10 Maternity Protection Act:
For each module there is an independent risk assessment according to §§ 10 et seqq. Maternity Protection Act (*MuSchG*). The modules are assessed according to
green = "no selection restrictions"
yellow = "some selection restrictions, individual agreement necessary"
red = "not selectable according to *MuSchG*"

The individual risk assessments can be found in the corresponding laboratories.

The central contact point for advice for pregnant or breastfeeding students is the family office of the Coburg University of Applied Sciences. Here you will also find an overview of risk assessment.

Table of Contents

1. Basic studies

Module name	**Business Administration 1**
Abbrev.	Bwl1
Format / SWH	Seminar-type lectures / 2 SWH
Credit points	2.5 ECTS
Work requirement	Total: 75 hrs, of which in-class: 30 hrs, self-study: 45 hrs.
Semester	1
Schedule	Annually
Duration of module	Single semester
Module coordinator	Dr. Georg Roth
Instructor(s)	Dipl. BA (FH) Nicole Strehl
Language	German
Use in other academic programs	AU, EL and EN
Admission requirements	None
Prerequisites	None
Qualification objectives / skills	Students will gain knowledge of essential basic concepts of general business administration and selected correlations from the following areas: legal forms, organization theory, personnel, strategic corporate policy, marketing
Course contents	**Basic concepts of general business administration** **Purpose and objectives of** **companies** **Legal forms** (corporations, partnerships, and mixed forms) and their business relevance Corporate Governance and its social significance **Organization of companies** - Importance of structural and process organization

	- Forms of organization in detail - Issues related to the improvement of process organization - Positions and job definition **Basic questions of human resources management** Significance and responsibilities of today's human resources management **Basic concepts in marketing** - Marketing strategies - Tools of the marketing mixes and their significance - Significance of customer loyalty and CRM
Study / examination grades contributing to final grade	Written partial examination (60 minutes)
Other performance tests	None
Media:	Projector, blackboard, overhead projector, self-directed study
Literature:	Känel, von Siegfried: Betriebswirtschaft für Ingenieure, Herne, NWB-Verlag, 2008 Schmalen, Helmut; Pechtl, Hans: Grundlagen und Probleme der Betriebswirtschaft, 14th edition, Stuttgart, Verlag Schäffer-Poeschel 2009 Wöhe, G.: Einführung in die Allgemeine Betriebswirtschaftslehre, 24th revised edition, Munich, Verlag Vahlen, 2010

Module name	**Business Administration 2**
Abbrev.	Bwl2
Format / SWH	Seminar-type lectures / 2 SWH
Credit points	2.5 ECTS
Work requirement	Total: 75 hrs, of which in-class: 30 hrs, self-study: 45 hrs.
Semester	2
Schedule	Annually
Duration of module	Single semester
Module coordinator	Dr. Georg Roth
Instructor(s)	Dipl. BA (FH) Nicole Strehl
Language	German
Use in other academic programs	AU, EL and EN
Admission requirements	None
Prerequisites	None
Qualification objectives / skills	Students will gain knowledge of essential basic concepts of general business administration and selected correlations from the following areas: production management, supply planning, ecology management, investment and financing, accounting
Course contents	**Foundations of the production management** - Production factors, production processes, manufactured products - Work planning - Quality management **Supply planning** - Conceptual delimitation and tasks of procurement - Provision of human capital (covering personnel requirements) - Provision of resources and consumption factors

	- Specifics of provision of resources (depreciation methods) - Specifics of the provision of consumption factors **Ecological management** **Foundations of investment and financing account** - Investment types - Main forms of financing - Static accounting procedures - Dynamic calculation methods **Fundamentals of accounting** - Structure and subareas of accounting - Tasks of accounting - Annual financial report with balance sheet and profit and loss statement **Fundamentals of strategic corporate policy** - Goals and instruments • Strengths-weaknesses analysis • Experience curve analysis • Product life-cycle analysis • Portfolio analysis
Study / examination grades contributing to final grade	Written partial examination (60 minutes)
Other performance tests	None
Media:	Projector, blackboard, overhead projector, self-directed study
Literature:	Känel, von Siegfried: Betriebswirtschaft für Ingenieure, Herne, NWB-Verlag, 2008 Schmalen, Helmut; Pechtl, Hans: Grundlagen und Probleme der Betriebswirtschaft, 14th edition, Stuttgart, Verlag Schäffer-Poeschel 2009 Wöhe, G.: Einführung in die Allgemeine Betriebswirtschaftslehre, 24th revised edition, Munich, Verlag Vahlen, 2010

Module name	**Digital Technology**
Abbrev.	Dt
Format / SWH	Seminar-type lectures (2 SWH), exercise (1 SWH), practical course (1 SWH) / 4 SWH
Credit points	4 ECTS
Work requirement	In-class time: 60 hrs, self-study: 60 hrs
Semester	3
Schedule	Annually
Duration of module	Single semester
Module coordinator	Dr. Matthias Mörz
Instructor(s)	Dr. Matthias Mörz, Dr. Matthäus Brela, Dr. Jochen Merhof
Language	German
Use in other academic programs	AU, EL and EN
Admission requirements	Eligibility to advance pursuant to §6 Para. 1 SPO
Prerequisites	Foundations of Electrical and Computer Engineering, Foundations of Digital Technology
Qualification objectives / skills	After the course students will be able to: • Securely describe the structure, function, and behavior of digital basic circuits and standard switching networks. • Use an oscilloscope and a logic analyzer to analyze logic circuits. • Describe and evaluate different types of memory and programmable logic devices. • Use a method for encoding signals. • Set up and evaluate different computation units. • Analyze and set up counter and frequency divider circuits. • Safely apply automata theory, state graphs, and circuit design methods. • Systematically design switching networks, switching circuits, and state machines and set them up in hardware.

Course contents	• Design of basic digital circuits • Logic gates and FlipFlops • Logic levels and I/O standards • Gate running times and gate transition times • Emergence of hazards and their prevention • Standard switching networks: multiplexer/demultiplexer, encoder/decoder, comparators, adders, subtractors, multipliers, ALU • Feedback switching networks and FlipFlops • Asynchronous and synchronous counters, frequency dividers • Design of the logic analyzer • Measurement and analysis of digital signals with the oscilloscope and the logic analyzer • Design of programmable logic devices: PLD, CPLD, FPGA • Design of memory blocks: ROM, EEPROM, Flash EPROM, SRAM, DRAM, SDRAM • Introduction to automata theory • Design of state machines with state sequence table and state graph • Foundations of coding • Applications of line codes • Foundations of source and channel coding: Data compression, detection and correction of transmission errors
Study / examination grades contributing to final grade	Written partial examination (90 minutes)
Other performance tests	None
Media:	Projector and blackboard/whiteboard, electronic scripts and working documents, calculation and simulation programs
Literature:	Beuth Klaus, Digitaltechnik – Elektronik 4, Vogel-Verlag Reichardt Jürgen, Lehrbuch Digitaltechnik, Oldenbourg-Verlag Fricke Klaus, Digitaltechnik, Vieweg-Verlag Dankmeier Wilfried, Grundkurs Codierung, Vieweg-Verlag

Module name	**Electrical Drives and Networks as Introduction to Power Engineering and Renewable Energies**
Abbrev.	EANz
Format / SWH	Seminar-type lectures (2 SWH), exercise (1 SWH), practical course (1 SWH) / 4 SWH
Credit points	5 ECTS
Work requirement	In-class time: 60 hrs, self-study: 90 hrs.
Semester	3
Schedule	Annually
Duration of module	Single semester
Module coordinator	Dr. Omid Forati Kashani
Instructor(s)	Dr. Omid Forati Kashani, Dr. Michael Rossner
Language	German
Use in other academic programs	AU, EL and EN
Admission requirements	Eligibility to advance pursuant to §6 Para. 1 SPO
Prerequisites	Knowledge of complex AC calculus, pointer diagrams, basic knowledge of magnetic field circuits and couplings and electronic components, basic knowledge of relationships of mechanical quantities.
Qualification objectives / skills	Students will be able to explain the fundamentals and operation of DC machines and converters for DC machines. They will be able to explain and understand the three-phase system and the structure, mode of action, and operating behavior of three-phase transformers, three-phase asynchronous and synchronous machines. They will be able to draw and apply various characteristic curves and time histories of the above components. They can analyze simple electromechanical tasks based on learned operating characteristics of the above-mentioned components and calculate electrical and mechanical quantities for steady-state operating conditions. In the subfield of networks, students will learn the basic principles of electrical power transmission and power considerations in three-phase networks. They will know the advantages

	and disadvantages of different network forms and their safety aspects and will be familiar with calculation methods for short-circuit currents, voltage drops, and cable dimensioning.
Course contents	• Direct current machine Structure and mode of operation, armature winding of a DC machine, air gap fields and operating behavior, voltage generation and torque, types of DC machines, characteristics and control of DC machines, no-load characteristic, speed-torque characteristic, procedure for changing speed, and structure and mode of operation of power converters for drives with a DC machine such as a buck converter, boost converter or DC converter (four-quadrant converter). • Three-phase system Rotatory voltage generation, generation of three-phase current (three-phase system), star and delta connection, three-phase power, power factor. • Three-phase transformer Construction and operation, types of construction, losses and efficiency, operating behavior, voltage equations and equivalent circuit, no-load operation and magnetization, transformer load, transformer short-circuit, and vector groups. • Three-phase asynchronous machine Generation of rotating magnetic fields, spatially offset windings, structure and mode of operation of the asynchronous machine, voltage equations and equivalent circuit, power balance, speed or slip torque characteristic, speed control of asynchronous machine, operating range of the three-phase asynchronous machine, starting, and special designs of the cage rotor. • Three-phase synchronous machine Structure and operation, equivalent circuit and vector diagram of solid pole machine, stationary island and mains operation of solid pole machine, V-curves of solid pole machine, torque and stability of solid pole machine, structure and special features of salient pole machine, and torque and stability of leg pole machine. • Subfield Networks Forms of energy transmission (direct current, alternating current, three-phase current), power and power measurement in the three-phase current network. Short circuit calculation (symmetrical and simple cases of asymmetrical SC).

	Network forms (TN, TT, IT), fuse elements, protection regulations. Structure of cables, types of installation, voltage drop calculations.

Module name	**Electrical Measurements**
Abbrev.	EMt
Format / SWH	Seminar-type lectures (3 SWH), exercise (0.5 SWH), practical course (0.5 SWH) / 4 SWH
Credit points	5 ECTS
Work requirement	In-class time: 60 hrs, self-study: 90 hrs.
Semester	2
Schedule	Annually
Duration of module	Single semester
Module coordinator	Dr.-Ing. Jochen Merhof
Instructor(s)	Dr.-Ing. Jochen Merhof
Language	German
Use in other academic programs	AU, EL and EN
Admission requirements	None
Prerequisites	Basic knowledge in electrical engineering and physics, Taylor and Fourier series development
Qualification objectives / skills	Technical-methodical competences • Students will have a basic understanding of the problems and significance of technical measurements. • They will be familiar with the important causes of measurement deviations and will be able to calculate and assess the effects of measurement uncertainty on measurement results. • They will understand how the most important analog and digital measuring instruments for electrical engineering work, their areas of application, and their limitations. • They will be familiar with the measurement of the basic electrical measurands and the most important measurement methods. • They will know averaging and spectral measurement values for the class of periodic measurands. • They will also have a basic understanding of digital measurement technology.

Course contents	• **Measurement uncertainty and error propagation** Measurement deviations and measurement uncertainty, systematic and random measurement deviations, measurement deviation as a random process, Gaussian error propagation, worst-case estimation. • **Measuring instruments** Measurement principle, design and characteristics of analog and digital multimeters, principle and operation of the analog and digital oscilloscope. • **Basic measuring methods** Current/voltage measurement, measuring range extension and measuring bridges, measurement of resistance and power, time and frequency and, if necessary, other quantities. • **Periodic measurands** Averaging of measured values from the time course, transformation into the frequency range, representation of periodic measured quantities as spectra and measured values derived from them, correlations between time course and spectrum. • **Digital metrology** Sampling and amplitude quantization, quantization uncertainty, analog/digital converter • **Practical experiments** In-depth study of the theoretically acquired contents, e.g. basic measurement methods, characteristics of periodic measurement signals.
Study / examination grades contributing to final grade	Written examination 90 min. and practical performance certificates
Media:	Projector and blackboard/whiteboard, electronic scripts and working documents, practical experiments in the laboratory.
Literature:	T. Mühl: Einführung in die elektrische Messtechnik B.G. Teubner R. Parthier: Messtechnik Vieweg+Teubner R. Lerch: Elektrische Messtechnik Springer

Module name	**Electronics 1 (Part 1)**
Abbrev.	El1A
Format / SWH	Seminar-type lectures with integrated exercises (3 SWH), practical course (1 SWH) / 4 SWH
Credit points	4 ECTS
Work requirement	In-class time: 60 hrs, self-study: 60 hrs.
Semester	2
Schedule	Annually
Duration of module	Single semester
Module coordinator	Dr. Alexander Stadler
Instructor(s)	Dr. Alexander Stadler
Language	German
Use in other academic programs	AU, EL and EN
Admission requirements	None
Prerequisites	Foundations of Electrical Engineering 1, Mathematics 1
Qualification objectives / skills	Subject-related skills: After completing this course, students will be able to: • Understand the conduction mechanisms and basic structures in semiconductors. • Calculate important properties of semiconductor devices. • Work with the characteristic curves of semiconductor devices. • Build and analyze basic circuits with the semiconductor devices. Methodological skills: After completing this course, students will be able to apply the interdisciplinary physical and electrical engineering principles specifically to analyze the conduction mechanisms in electronic devices. They will understand the structure of practical circuits and be able to determine the essential functional parameters using both

	simulation as well as laboratory measurements. For specialization and better understanding, the practical part of the course includes the metrological investigation of some important semiconductor components.
Course contents	• Introduction (electronics and electronic components, conceptual classification, delimitation and subdivision, historical development, economic significance, social significance) • Physical basics of semiconductor electronics (charge carriers in semiconductors, pn-junction and diode, metal-semiconductor junctions, MOS structure) • Semiconductor diodes (working with characteristics, rectifier diode, switching diode, Z-diode, varactor diodes, Schottky diode, tunnel diode, microwave diodes, photodiode, solar cell, light emitting diode and laser diode) • Transistors (bipolar transistor, field effect transistors, special transistors) • Thyristors (structure and operation, electrical properties, special forms - GTO, TRIAC, DIAC) • Operational amplifiers (characteristics, principle of negative feedback, basic circuits, internal construction, offset compensation, frequency response and frequency response correction, slew rate)
Study / examination grades contributing to final grade	Written part examination 90 min. and practical part study work
Other performance tests	None
Media:	Blackboard, projector, whiteboard, printed lecture notes with exercises, electronically provided accompanying material
Literature:	E. Böhmer, Elemente der Elektronik – Repetitorium und Prüfungstrainer: Ein Arbeitsbuch mit Schaltungs- und Berechnungsbeispielen, Vieweg+Teubner Verlag, 6th completely revised and expanded edition, 2005, ISBN-10: 352854189X E. Böhmer, D. Ehrhardt, W. Oberschelp, Elemente der angewandten Elektronik: Kompendium für Ausbildung und Beruf, Vieweg+Teubner Verlag, 15th updated and expanded edition, 2007, ISBN-10: 3834801240 H. Göbel, Einführung in die Halbleiter-Schaltungstechnik, Verlag Springer Vieweg, 5th updated edition, 2014, ISBN-10: 3642538681

	H. Göbel, H. Siemund, Übungsaufgaben zur Halbleiter-Schaltungstechnik, Verlag Springer Vieweg, 3rd edition, 2014, ISBN-10: 3642539025 S. Goßner, Grundlagen der Elektronik – Halbleiter, Bauelemente und Schaltungen, Shaker-Verlag, 8th updated edition, 2011, ISBN-10: 3826588258 R. Müller, Bauelemente der Halbleiter-Elektronik, Springer-Verlag, 4th revised edition, 1991, ISBN-10: 3540544895 R. Müller, Grundlagen der Halbleiter-Elektronik, Springer-Verlag, 7th corrected edition, 2008, ISBN-10: 3540589120 M. Reisch, Elektronische Bauelemente: Funktion, Grundschaltungen, Modellierung mit SPICE, Springer-Verlag, 2nd edition, 2006, ISBN-10: 3540340149 M. Reisch, Halbleiter-Bauelemente, Springer-Verlag, 2nd revised edition, 2007, ISBN-10: 3540731997 F. Thuselt, Physik der Halbleiterbauelemente: Einführendes Lehrbuch für Ingenieure und Physiker, Springer-Verlag, 2nd edition, 2011, ISBN-10: 3642200311 U. Tietze, C. Schenk, Halbleiter-Schaltungstechnik, Springer-Verlag, 12th edition, 2002, ISBN-10: 3540428496

Module name	**Electronics 1 (Part 2)**
Abbrev.	El1B
Format / SWH	Seminar-type lectures with exercises (3 SWH) and practical course (1 SWH) / 4 SWH
Credit points	4 ECTS
Work requirement	60 hrs. in-class 90 hrs. self-study
Semester	3
Schedule	Annually
Duration of module	Single semester
Module coordinator	Dr. Alexander Stadler
Instructor(s)	Dr. Alexander Stadler Dr. Hans-Martin Tröger Dr. Christian Weindl
Language	German
Use in other academic programs	AU, EL and EN
Admission requirements	Eligibility to advance pursuant to §6 Para. 1 SPO
Prerequisites	Foundations of Electrical Engineering, Measurement Technology and Electronics, GE 1, Mathematics 1, Programming 1
Qualification objectives / skills	Students will learn the basic applications of electronic components in amplifier and switch applications. They will learn to synthesize and dimension larger electronic circuits from simple basic elements. In the practical part, they will become familiar with the practical implementation, metrological verification and simulation of the circuits.
Course contents	Characteristics and equivalent circuits of diodes and transistors Basic circuits of semiconductor electronics: Voltage and current sources Small signal amplifiers DC amplifiers Differential amplifiers with bipolar transistors and FETs

	Power amplifiers and power switches Operational amplifiers and their applications Linear and clocked power supplies
Study / examination grades contributing to final grade	Written exam (90 min), practical performance test (4 experiments with elaborations), practical course final exam
Other performance tests	None
Media:	Blackboard, overhead/projector Electronically and in paper form provided working documents and exercises, experimental instructions for the practical part of the course Freeware programs such as LTSpice, QucsStudio or TI FilterPro
Literature:	Tietze-Schenk: Halbleiter-Schaltungstechnik, Springer-Verlag, 14th edition 2012 Horowitz-Hill: The Art of Electronics, Cambridge University Press, 3rd edition 2015 Robert A. Pease: Troubleshooting Analog Circuits, Newnes 1993

Module name	**English 1 (GER B2)**
Abbrev.	Eng1
Format / SWH	Seminar-type lectures with exercises / 2 SWH
Credit points	2.5 ECTS
Work requirement	In-class time: 30 hrs, self-study: 45 hrs.
Semester	1
Schedule	Annually
Duration of module	Single semester
Module coordinator	B. Craven, M.A.
Instructor(s)	B. Craven, M.A. / R. Fry, MCLFS
Language	English
Use in other academic programs	AU, EL and EN
Admission requirements	None
Prerequisites	Recommended: Preliminary knowledge of target language GER B1
Qualification objectives / skills	Subject-related skills • Advanced active and passive language skills (speaking, writing, listening comprehension, reading) at least at language competence level B2 • Specialist focus: technical vocabulary, correspondence • Job-specific focus: interviewing, job interviews Methodological competence • Acquisition of learning strategies that enable autonomous learning; certain tasks enable reflection on the employed strategies Intercultural competence • Use of the appropriate language (e.g. registers, courtesies) in intercultural interactions in professional and social situations • Knowledge of English-speaking countries Learning competence

	• Self-learning skills reinforced by the *blended learning* concept
Course contents	• Changing technical topics (e.g. robotics, circuit systems, environmental technology, renewable energies) • Professional correspondence: E-mails, formal correspondence • Technical writing: Reporting, process flow • Application process: Curriculum vitae, letter of application, job interview
Study / examination grades contributing to final grade	Other written partial examination 60 min.
Other performance tests	None
Media:	Projector, blackboard, visualizer
Literature:	Script

Module name	**English 2 (GER B2)**
Abbrev.	Eng2
Format / SWH	Seminar-type lectures with exercises / 2 SWH
Credit points	2.5 ECTS
Work requirement	In-class time: 30 hrs, self-study: 45 hrs
Semester	2
Schedule	Annually
Duration of module	Single semester
Module coordinator	B. Craven, M.A.
Instructor(s)	B. Craven, M.A. / R. Fry, MCLFS
Language	English
Use in other academic programs	AU, EL and EN
Admission requirements	None
Prerequisites	Recommended: Preliminary knowledge of target language GER B1
Qualification objectives / skills	Subject-related skills • Advanced active and passive language skills (speaking, writing, listening comprehension, reading) at least at language competence level B2 • Specialist focus: technical vocabulary, correspondence • Job-specific focus: interviewing, job interviews Methodological competence • Acquisition of learning strategies that enable autonomous learning; certain tasks enable reflection on the employed strategies Intercultural competence • Use of the appropriate language (e.g. registers, courtesies) in intercultural interactions in professional and social situations • Knowledge of English-speaking countries Learning competence

	• Self-learning skills reinforced by the *blended learning* concept
Course contents	• Changing technical topics (e.g. robotics, circuit systems, environmental technology, renewable energies) • Professional correspondence: E-mails, formal correspondence • Technical writing: Reporting, process flow • Application process: Curriculum vitae, letter of application, job interview
Study / examination grades contributing to final grade	Other written partial examination 60 min.
Other performance tests	None
Media:	Projector, blackboard, visualizer
Literature:	Script

Module name	**Foundations of Electrical Engineering 1**
Abbrev.	GE1
Format / SWH	Seminar-type lectures (6 SWH), exercise (2 SWH) / 8 SWH
Credit points	8 ECTS
Work requirement	In-class time: 120 hrs, self-study: 120 hrs.
Semester	1
Schedule	Annually
Duration of module	Single semester
Module coordinator	Dr. Bernd Hüttl
Instructor(s)	Dr. Bernd Hüttl, Dr. Michael Rossner
Language	German
Use in other academic programs	AU, EL and EN
Admission requirements	None
Prerequisites	Mastery of geometry and algebra and systems of linear equations; knowledge of integral, differential, and vector calculus; basic knowledge of physics at "*Abitur*" level.
Qualification objectives / skills	Technical-methodical competences • Students will master the basic physical quantities for describing electrical networks, as well as electric and magnetic fields. • They will understand the basic equations describing electric and magnetic fields and will be able to calculate fields of simple geometries. • They will be familiar with Maxwell's equations in vector analytical representation and understand their meaning. • They will recognize the importance of these fundamentals for the design of electrical equipment and circuits and be able to perform calculations yourself using simple examples. • They will learn the structure of simple DC networks and master the basic rules of network calculation.

	• Based on this, they will be able to apply generally applicable calculation methods for more complex DC circuits and to analyze and calculate transient processes in linear networks with an energy storage device.
Course contents	• **Electric field** Clarification of terms: charge, field strength, voltage, potential, and capacitance Calculation of electrostatic fields and potential fields for simple geometries Matter in electric field and polarization; energy and forces in electric field Fields of stratified arrangements Electric flow field • **Magnetic field** The static magnetic field in vacuum: Magnetic phenomena, Lorentz force and magnetic flux density, Ampere's circuit law and magnetic field strength The magnetic field in matter: Paramagnetism, diamagnetism and ferromagnetism Permeability Simple magnetic circuits Electromagnetic voltage generation: Motion and rest induction, self-induction, and self-inductance Mutual induction and mutual inductance Energy and forces in the magnetic field • **Linear DC networks** The DC electric circuit: Ohm's law, mesh and node rule, voltage and current divider Ideal and real voltage and current sources: Source conversion, matching and power balance Network calculation methods: Star-delta conversion, equivalent source method, superposition method, mesh current and node potential method Controlled sources in four-pole representation • **Switching operations in linear networks** Classes and terminal behavior of linear two-terminal systems Approach and solution of differential equations for the calculation of switching on and off processes in ohmic-inductive or ohmic-capacitive networks Periodic switching
Study / examination grades contributing to final grade	Written partial examination (150 minutes)
Other performance tests	None

Media:	Projector and blackboard/whiteboard, electronic scripts and working documents, and practice exercises.
Literature:	A. Führer, K. Heidemann, W. Nerreter: Grundgebiete der Elektrotechnik, Carl Hanser Verlag R. Paul: Elektrotechnik Vol. I, Springer Verlag W.-E. Büttner: Grundlagen der Elektrotechnik I, Oldenbourg Verlag M. Albach: Grundlagen der Elektrotechnik 1 und 2, Pearson Studium

Module name	**Foundations of Electrical Engineering 2**
Abbrev.	GE2
Format / SWH	Seminar-type lectures / 4 SWH
Credit points	4 ECTS
Work requirement	In-class time: 60 hrs. self-study: 60 hrs.
Semester	2
Schedule	Annually
Duration of module	Single semester
Module coordinator	Dr. Bernd Hüttl
Instructor(s)	Dr. Bernd Hüttl
Language	German
Use in other academic programs	AU, EL and EN
Admission requirements	None
Prerequisites	Knowledge of complex calculus, basic understanding of electric and magnetic fields, calculation methods for linear networks.
Qualification objectives / skills	Subject-related skills: After the course, students will be able to: • Apply the knowledge and skills acquired in the first semester to the analysis of direct current networks. Extend this knowledge to linear AC networks in steady state, using the complex AC computation. • Recognize important AC electrical network configurations, name their practical significance, and analyze and calculate such network configurations. • Represent and calculate the interrelationships of the transformer in steady state operation. These skills are based on an electrical equivalent circuit and an understanding of the operating characteristics under different operating conditions and load characteristics.

Course contents	• **AC power systems** Description of steady-state sinusoidal oscillations by complex RMS values, passive linear two-terminal circuits described as complex resistances and conductances, simple LRC circuits (series and parallel), branched circuits, oscillating circuits and transformation four-terminal circuits, application of locus diagrams, bode diagrams, four-terminal coefficients, and computational methods for analysis of complex networks. • **AC transformer** Description of the ideal transformer, consideration and calculation of losses and dispersion in the transformer, real single-phase transformers in steady-state operation: Equivalent circuit, pointer diagram. Simplified considerations in open circuit and short circuit. Operating behavior in nominal operation with resistive, resistive-inductive and resistive-capacitive load.
Study / examination grades contributing to final grade	Written partial examination (90 minutes)
Other performance tests	None
Media:	Blackboard, projector, Moodle platform Handouts and exercises provided in electronic format
Literature:	A. Führer, K. Heidemann, W. Nerreter: Grundgebiete der Elektrotechnik, Vol. 2, Hanser Verlag S. Altmann, D. Schlayer: Lehr- und Übungsbuch Elektrotechnik, Hanser Verlag R. Ose: Elektrotechnik für Ingenieure, Hanser Verlag

Module name	**Mathematics 1**
Abbrev.	Mth1
Format / SWH	Seminar-type lectures, integrated exercises / 8 SWH
Credit points	8 ECTS
Work requirement	In-class time: 120 hrs. self-study: 120 hrs.
Semester	1
Schedule	Annually
Duration of module	Single semester
Module coordinator	Dr. Bernd Hüttl
Instructor(s)	Dr. Bernd Hüttl and Dr. Rainer Dohlus
Language	German
Use in other academic programs	AU, EL and EN
Admission requirements	None
Prerequisites	None
Qualification objectives / skills	After the course students will be able to: **concerning technical skills** - Understand basic mathematical thinking and concepts - Apply mathematical procedures and techniques **concerning methodological skills** - Mathematically understand and solve physics/engineering problems
Course contents	**Foundations:** Logic, algebra of sets, real and complex numbers, equations and inequalities, functions and curves. **Linear Algebra:** Vectors, matrices, determinants, and systems of equations. **Limits**: Sequences and series **Differential and integral calculus** **First order ordinary differential equations**

Study / examination grades contributing to final grade	Written partial examination (120 minutes)
Other performance tests	None
Media:	Oral and written lectures with blackboard and video projector, electronic scripts and workbooks, calculation exercises via Moodle, etc.
Literature:	Papula: Mathematik für Ingenieure I – III Meyberg/Vachenauer: Höhere Mathematik I und II

Module name	**Mathematics 2**
Abbrev.	Mth2
Format / SWH	Seminar-type lectures, integrated exercises / 4 SWH
Credit points	4 ECTS
Work requirement	In-class time: 60 hrs. self-study: 60 hrs.
Semester	2
Schedule	Annually
Duration of module	Single semester
Module coordinator	Dr. Matthäus Brela
Instructor(s)	Dr. Matthäus Brela
Language	German
Use in other academic programs	AU, EL and EN
Admission requirements	None
Prerequisites	Methods and Skills of Mathematics 1
Qualification objectives / skills	Subject-related skills: After the course, students will be able to: • Apply basic mathematical thinking, concepts, and techniques. • Understand, formulate, and solve technical problems mathematically. • Recognize higher order ordinary linear differential equations and systems of differential equations in their properties, develop appropriate solution strategies, and successfully implement them. • Apply the Laplace transformation with its specific properties to solve mathematical problems, especially to solve linear ordinary differential equations. • Analyze and represent scalar functions of several variables in behavior and subject these functions to differential and integral operations to solve engineering problems.

	• Apply basic vector analytic operations to vector fields, especially to perform electrical engineering field calculations.
Course contents	• Higher order ordinary linear differential equations and systems of differential equations: Properties of ordinary linear differential equations, solution concepts for solving homogeneous and inhomogeneous differential equations, fitting solutions to constraints, solving simple systems of differential equations, emphasis on second order differential equations. • Laplace transformation: Properties of the integral operator and computational concepts for transformations from original to image space and back; application of the Laplace operator to problems of differentiation and integration; and application to ordinary differential equations of higher order • Scalar functions of several variables: Representation and analysis (continuity and extrema), calculation of limits, application of differentiation and integration operations • Vector analysis: Introduction, representation and analysis of vector fields, application of differential operators and integrations for simple field calculations.
Study / examination grades contributing to final grade	Written partial examination (90 minutes)
Other performance tests	None
Media:	Blackboard, projector, Moodle platform Handouts and exercises provided in electronic format
Literature:	Papula: Mathematik für Ingenieure, Vols 2 und 3 Meyberg/Vachenauer: Höhere Mathematik Vols 1 and 2 Stingl: Mathematik für Fachhochschulen

Module name	**Mathematics 3**
Abbrev.	Mth3
Format / SWH	Seminar-type lectures / 4 SWH
Credit points	4 ECTS
Work requirement	In-class time: 60 hrs, self-study: 60 hrs.
Semester	3
Schedule	Annually
Duration of module	Single semester
Module coordinator	Dr. Martin Springer
Instructor(s)	Dr. Martin Springer
Language	German
Use in other academic programs	AU, EL and EN
Admission requirements	Eligibility to advance pursuant to §6 Para. 1 SPO
Prerequisites	Methods and Skills of Mathematics 1 and 2
Qualification objectives / skills	Application of the z-transform to the treatment of difference equations, Knowledge and application of the Fourier integral and the discrete Fourier transform, Knowledge of basic stochastics, solving problems in combinatorics, Application of basic probability distributions
Course contents	The z-transform and its application to difference equations: • Properties • Application to LTI systems The Fourier transform • Fourier series • Fourier integral • Discrete Fourier transform

	Stochastics • Descriptive statistics • Combinatorics • Probability spaces • Distributions
Study / examination grades contributing to final grade	Written partial examination (90 minutes)
Other performance tests	None
Media:	Blackboard Overhead projector PC
Literature:	e.g. L. Papula: Mathematik für Ingenieure. Vieweg + Teubner (div. editions) Burg, K.: Höhere Mathematik für Ingenieure; vol. 3. Vieweg+Teubner, 2009 Butz, T.: Fourier-Transformation für Fußgänger. Vieweg+Teubner, 2009 Oppenheim, A.V., Willsky: Signale und Systeme. VCH, 1992 Bosch, K.: Elementare Einführung in die Wahrscheinlichkeitsrechnung. Vieweg+Teubner, 2010 Henze, N.: Stochastik für Einsteiger. Vieweg+Teubner, 2010

Module name	**Microcomputer Technology**
Abbrev.	MCT
Format / SWH	4 SWH: – Seminar-type lectures (2 SWH) – Exercise (1 SWH) and practical course (1 SWH)
Credit points	5 ECTS
Work requirement	In-class time: 60 hrs, self-study: 90 hrs.
Semester	3
Schedule	Annually
Duration of module	Single semester
Module coordinator	Dr. Peter Johann Raab
Instructor(s)	Dr. Peter Johann Raab
Language	German
Use in other academic programs	IF, EL and EN
Admission requirements	Eligibility to advance pursuant to §6 Para. 1 SPO
Prerequisites	Fundamentals of computer science and programming
Qualification objectives / skills	**Subject-related skills:** – Recognition of structures and assessment of the properties of hardware and software components of modern microcomputer systems – Development of software for microcomputer systems, incl.: – Machine-oriented programming in assembly – Analysis and implementation of real time properties – Development with the help of asynchronous events (interrupts) – Control of typical input/output devices – Use of modern development and debugging tools **Interdisciplinary skills:** – Teamwork – Analysis and implementation of requirements into a
Course contents	Foundations:

	Overview of structure, application areas and requirements of embedded systems, hardware and abstractions, structure of ARM-based microcontrollers Programming: Assembler programming, addressing modes, computer arithmetic and loop programming, number systems, arithmetic and logic operations, program structures, subroutines, stack, interrupts, timers and counters, real-time behavior, synchronous and asynchronous software design, high level language reference (embedded C, compiler). Input/output systems: Digital I/O, interfaces, UART, bus systems, access methods, analog signals, and conversion. Practical application: Use of modern development tools (debugging, real-time emulation), configuration of a current practice-oriented system of prefabricated hardware components (e.g. keyboards, LCD displays, GPS receivers, RFID devices, Bluetooth transmitters, transducers, stepper motor control, DCF receivers, printing unit control), application of hardware-related (assembly) programming for a complex application using various hardware components.
Study / examination grades contributing to final grade	Written examination (90 minutes) and prStA (experiments and surveys)
Other performance tests	None
Media	Slides / lecture script / lab use
Literature	Michael Engel, "Maschinennahe Programmierung mit arm Cortex-M-Prozessoren" (in preparation) Joseph Yiu, "The Definitive Guide to ARM Cortex-M3 and Cortex-M4 Processors," Newnes, 3rd edition 2013, ISBN-13: 978-0124080829 Jonathan M. Valvano, "Embedded Systems: Introduction to ARM Cortex-M Microcontrollers," CreateSpace Independent Publishing, 2nd ed. 2012, ISBN-13: 978-1477508992

Module name	**Physics**
Abbrev.	Ph
Format / SWH	Seminar-type lectures (3 SWH), integrated exercise, practical course (1 SWH) / 4 SWH
Credit points	5 ECTS
Work requirement	In-class time: 60 hrs, self-study: 90 hrs.
Semester	1
Schedule	Annually
Duration of module	Single semester
Module coordinator	Dr. Martin Springer
Instructor(s)	Dr. Martin Springer, Dr. Christian Weindl
Language	German
Use in other academic programs	AU, EL and EN
Admission requirements	None
Prerequisites	Basic mathematical knowledge
Qualification objectives / skills	Subject-related skills: After the course, students will be able to: • Theoretically understand physical problems in mechanics and wave physics, develop practical solutions and successfully implement them. • Analyze and quantitatively describe physical and technical problems. Interdisciplinary skills • The acquired knowledge of physics and the developed ability to create solution concepts are understood as a basis for the advanced courses in electrical engineering. Methodological competence • Students will learn to understand experiments as projects, ranging from independent planning and

	execution to achieving results and assessing accuracy. Social competence • Working in project groups while performing experiments develops the ability to solve problems in a team.
Course contents	• Measurement techniques: Measurement of physical quantities, error determination of measurements and measurement series, error propagation law, and regression analysis. • Mechanics: Kinematics and dynamics of mass points, dynamics of reference systems, mechanical energy and momentum, conservation laws, mechanical collisions, mechanical oscillations and waves, and their superimpositions • Wave optics: Mathematical description of optical waves and of wave packets, diffraction, interference and coherence of optical waves, dispersion and refraction law of waves, and optical radiation sources
Study / examination grades contributing to final grade	Written examination 90 min. and practical performance certificates
Other performance tests	None
Media:	Blackboard, projector, Moodle platform Handouts and exercises provided in electronic format
Literature:	Hering/Martin/Stohrer: Physik für Ingenieure, Springer Verlag, Berlin 2012, 11th edition Gerthsen: Physik, Springer Verlag, Berlin 2010, 24th edition

Module name	**Programming 1**
Abbrev.	Prg1
Format / SWH	Seminar-type lectures (2 SWH), exercise (2 SWH) / 4 SWH
Credit points	4 ECTS
Work requirement	In-class time: 60 hrs. self-study: 60 hrs.
Semester	1
Schedule	Annually
Duration of module	Single semester
Module coordinator	Dr. Wolfram Haupt
Instructor(s)	Dr. Wolfram Haupt
Language	German
Use in other academic programs	AU, EL and EN
Admission requirements	None
Prerequisites	None
Qualification objectives / skills	Students will be able to classify computer science and programming in the field of electrical engineering. In addition, they will be familiar with the basic terms required for communication in the field of computer science. They will also know the basic structure of a computer and how it works in principle. Students will be able to handle important number systems and also convert them. Furthermore, students will be able to create their own small programs to solve textually described problems using algorithms. Students will use different elements for the controlling the workflow of a program and can use them for the solution.

Course contents	Theory: • Programming in electrical engineering - Why? • Structure of a computer • How a computer works • Number system - bits & bytes • How does a compiler or interpreter work? Practice: • Programs - what are they used for? • What are algorithms? • Basic elements of Python • Debugging or dealing with errors • Turtle graphics • Python modules • Functions • Conditions • More about iteration • Strings • Lists • Files • NumPy + Matplotlib
Study / examination grades contributing to final grade	Written partial examination (90 minutes)
Other performance tests	None
Media:	Common presentation techniques, books, script and presentation slides as well as exercises (partly with solutions) on the intranet. Further use of an eLearning platform. Additional use of hardware in the exercises.
Literature:	Interactive script additionally: Allen B. Downey, Think Python

Module name	**Programming 2**
Abbrev.	Prg2
Format / SWH	Seminar-type lectures (2 SWH), PC / project exercises (2 SWH) / 4 SWH
Credit points	4 ECTS
Work requirement	In-class time: 60 hrs, self-study: 60 hrs.
Semester	2
Schedule	Annually
Duration of module	Single semester
Module coordinator	Dr. Christian Weindl
Instructor(s)	Dr. Christian Weindl
Language	German
Use in other academic programs	AU, EL and EN
Admission requirements	None
Prerequisites	• Basic knowledge of imperative programming • Basics of using an integrated development environment (IDE) • Handling binary numbers • Basics of Boolean algebra
Qualification objectives / skills	Subject-related and methodological skills: Students will be able to: • Classify tasks and programming solutions in the field of electrical engineering. • Handle and convert important number systems. • Create their own, smaller programs to solve textually described problems using algorithms. • Create and maintain programs with readable and maintainable source code. • Use different elements for controlling the workflow of a program and use them for the solution. • Understand and apply known algorithms from different application areas. • Understand suitable data structures and techniques for algorithm design and apply them to non-trivial problems.

	• Know, understand, and apply algorithm analysis with respect to complexity, memory requirements, etc.
Course contents	• Programming tasks in electrical engineering • Number systems - bits & bytes • Function of interpreters and compilers • Selected software engineering techniques - Encapsulation and modularity • File access in C • Recursion and iteration • Dynamic memory management • Algorithms: e.g. searching, sorting, etc. • Data structures: Stacks, lists, queues, trees, etc. • Comparison: C and C++ • Insight into advanced programming techniques: GUIs, object orientation, etc.
Study / examination grades contributing to final grade	Written partial examination (90 minutes)
Other performance tests	None
Media:	Projector, presentation slides, blackboard, whiteboard, exercises in electronic form (some with solutions). If necessary, use of an e-learning system. Additional use of hardware in the exercises.
Literature:	Ottmannn/Widmayer: Algorithmen und Datenstrukturen, 5th edition, Spektrum Akademischer Verlag, 2012 Saake/Sattler: Algorithmen und Datenstrukturen, dpunkt.verlag, 2014 Robert C. Martin, "Clean Code", Prentice Hall, 2009 Collins-Sussman/Fitzpatrick/Pilato, Version Control with Subversion, http://svnbook.red-bean.com/index.de.html Additional C literature: Internet documents and literature in reading room

Module name	**Signals and Systems as an Introduction to Electrical Engineering and Information**
Abbrev.	SuS
Format / SWH	Seminar-type lectures (3 SWH), exercise (1 SWH) / 4 SWH
Credit points	4 ECTS
Work requirement	In-class time: 60 hrs, self-study: 60 hrs.
Semester	3
Schedule	Annually
Duration of module	Single semester
Module coordinator	Dr. Matthias Mörz
Instructor(s)	Dr. Matthias Mörz
Language	German
Use in other academic programs	AU, EL and EN
Admission requirements	Eligibility to advance pursuant to §6 Para. 1 SPO
Prerequisites	Fundamentals of electrical engineering, electronic components, circuit technology
Qualification objectives / skills	After the course students will be able to: • Explain and evaluate the basic properties of signals and systems. • Describe and calculate linear time-invariant (LTI) systems in their continuous-time representation (linear differential equations, convolution operation, convolution integral). • Describe and calculate continuous LTI systems in the frequency domain (Fourier transformation). • Describe and calculate continuous LTI system in the image domain (Laplace transformation) • Explain the sampling operation with its meaning in the time and frequency domain. • Describe and calculate linear time invariant (LTI) systems in their discrete time representation (z-transform)

Course contents	• Transition to normalized signals • Continuous-time elementary signals • Linear time invariant (LTI) systems - continuous time • System description with linear differential equations • Impulse, step and ramp response of LTI systems • Convolution operation • System description with the help of Laplace transforms • Transfer function • Block diagram algebra • Frequency response and Bode diagram • Frequency response of elementary systems (P,I,D,PT1,PD,DT1) • Linear time invariant (LTI) systems - discrete time • Sampling (time and frequency domain) • Elementary (discrete-time) signal sequences • Step and impulse response • Convolution • Z-transform
Study / examination grades contributing to final grade	Written examination 90 min.
Other performance tests	None
Media:	Projector and blackboard/whiteboard, electronic scripts and working documents, calculation programs
Literature:	Scheithauer Rainer, Signale und Systeme, Teubner-Verlag Werner Martin, Signale und Systeme, Vieweg+Teubner-Verlag

Module name	**Control Technology as an Introduction to Automation Technology and Robotics**
Abbrev.	StRt
Format / SWH	Seminar-type lectures (3 SWH), practical course (1 SWH) / 4 SWH
Credit points	4 ECTS
Work requirement	In-class program: 60 hrs. self-study: 60 hrs.
Semester	3
Schedule	Annually
Duration of module	Single semester
Module coordinator	Dr. Matthäus Brela
Instructor(s)	Dr. Matthäus Brela
Language	German
Use in other academic programs	AU, EL and EN
Admission requirements	Eligibility to advance pursuant to §6 Para. 1 SPO
Prerequisites	Foundations of electrical circuitry and engineering mechanics. Linear differential equations.
Qualification objectives / skills	• Students will: Know the difference between control and regulation. • Know the basic principle of discrete-event controls and can apply their modeling to simple examples of automation technology. • Know selected standards of programmable logic controllers and programming languages and will be able to create simple control programs. • Know the difference between analog, digital and binary signals and will be able to process them in terms of control technology. • Know the basic technical structure of control, regulation and automation systems. • Understand the basic principle of the feedback control loop and its breakdown into different function blocks.

	• Know the control system concept and will be able to mathematically model simple dynamic systems of electrical engineering, mechanics, and process engineering. • Be familiar with the most important controller types, will be able to analyze their influence on the system behavior, and will know application areas as well as design methods by means of selected setting rules for the controller parameters. • Be able to design, program and test the basic controllers in software.
Course contents	• **Control technology** Discrete event control, programming according to IEC61131-3 in the languages ST, FBD, LD, IL, reading sensor data, processing control data, and setting actuators. • **Technology of monitoring, control and automation systems** Basic system structure and components, memory functions, edge evaluation, time functions, clock signals, counting functions, and other basic links. Programming of transfer functions. • **Basic structure of the standard control loop** Controller, controlled system, actuators and sensors, reference variables, controlled variables, manipulated variables, and disturbance variables. Representation of a control loop as block structure, differential equation, and transfer function. • **Controlled systems** Proportional and integrating controlled systems with and without time delay constants, dead time element, description by linear differential equations, and determination of the system parameters from the step response. • **Control** Important controller types, their characteristic values and application, control and disturbance behavior, and adjustment rules for optimizing the control loop behavior. • **Practical course:** Acquisition of sensor signals, introduction to motion control, interaction of controller and segment
Study / examination grades contributing to final grade	Written examination 90 min. and practical performance certificates
Other performance tests	None

Media:	Blackboard, overhead/projector Electronically provided working documents and exercises Computer-aided development and simulation environments
Literature:	H. Unbehauen: Regelungstechnik I: Klassische Verfahren zur Analyse und Synthese linearer kontinuierlicher Regelsysteme, Fuzzy-Regelsysteme, Vieweg Verlag J. Kahlert: Crash-Kurs Regelungstechnik, VDE Verlag GmbH W. Schneider: Praktische Regelungstechnik, Vieweg+Teubner Verlag F. Tröster: Steuerungs- und Regelungstechnik für Ingenieure, Oldenbourg Wissenschaftsverlag

Module name	**Computer Engineering**
Abbrev.	TI
Format / SWH	Seminar-type lectures (3 SWH), exercise (1 SWH) / 4 SWH
Credit points	4 ECTS
Work requirement	In-class time: 60 hrs, self-study: 60 hrs.
Semester	2
Schedule	Annually
Duration of module	Single semester
Module coordinator	Dr. Matthias Mörz
Instructor(s)	Dr. Matthias Mörz
Language	German
Use in other academic programs	AU, EL and EN
Admission requirements	None
Prerequisites	Foundations of electrical engineering and computer science
Qualification objectives / skills	After the course students will be able to: • Deal confidently with logic operations and the calculation and simplification rules of circuit algebra. • Analyze logic circuits. • Amplify logic operations with the Karnaugh-Veitch diagram and according to Quine & McCluskey. • Develop and build logic circuits. • Explain the essential differences in the use of different circuit families in circuit realization and take them into account in circuit construction. • Build and evaluate simple arithmetic circuits. • Analyze and build time-dependent binary circuits (counters, frequency dividers).
Course contents	• Logical operations • Boolean algebra, circuit algebra • Basic functions and composite elements • Circuit analysis • Construction of logic circuits with different circuit families • Circuit synthesis

	• Normal forms (DNF, KNF) • Minimization methods: Karnaugh-Veitch / KV diagram, Quine McCluskey • Binary codes • Combinatorial logic functions / standard circuit networks: Encoder, decoder, multiplexer, comparator, adder, subtractor • Time-dependent binary circuits, counters, and frequency dividers
Study / examination grades contributing to final grade	Written partial examination (90 minutes)
Other performance tests	None
Media:	Projector and blackboard/whiteboard, electronic scripts and working documents, calculation and simulation programs
Literature:	Beuth, Digitaltechnik – Elektronik 4, Vogel-Verlag Schiffmann, Schmitz: Technische Informatik 1, Springer-Verlag Becker, Drechsler, Molitor: Technische Informatik, Pearson-Verlag

2. Required Internship Semester

Module name	**Internship Seminar**
Abbrev.	PxLv
Format / SWH	Seminar-type lectures, practical course, project work / 4 SWH
Credit points	5 ECTS
Work requirement	In-class time 60 hrs, self-study 90 hrs.
Semester	4
Schedule	Annually
Duration of module	Single semester
Module coordinator	Dr. Matthias Mörz
Instructor(s)	Various lecturers and adjunct professors
Language	German
Use in other academic programs	AU, EL and EN
Admission requirements	Eligibility to advance pursuant to §6 Para. 2 SPO
Prerequisites	None
Qualification objectives / skills	• Students will know and reflect on selected topics that are particularly relevant for the tasks undertaken in the required internship. • They will develop and perfect techniques, skills and soft skills that are highly relevant for a job in a company. • They will share experiences with professional colleagues and recognize the benefits of networking.
Course contents	As specified in the study and examination plan
Study / examination grades contributing to final grade	None
Other performance tests	Practical performance and participation certificates
Media:	
Literature:	

Module name	**Practical Seminar**
Abbrev.	Pxsem
Format / SWH	Seminar / 2 SWH
Credit points	2 ECTS
Work requirement	In-class time: 30 hrs, self-study: 30 hrs.
Semester	4
Module coordinator	Dr. Matthias Mörz
Instructor(s)	Dr. Matthias Mörz
Language	German
Use in other academic programs	AU, EL and EN
Admission requirements	Eligibility to advance pursuant to §6 Para. 2 SPO
Prerequisites	None
Qualification objectives / skills	• Students will be able to present an analysis of a task in their field of study in writing and orally in an appropriate form, which they have prepared themselves. • They will know basic rules for writing scientific/academic papers and will be able to apply them independently. • They will further develop their ability to present subject-specific content in front of an expert audience.
Course contents	Depending on the tasks worked on during the required internship.
Study / examination grades contributing to final grade	None
Other performance tests	Written practical report (approx. 20 pages), oral, media-supported presentation (approx. 15 minutes)
Media:	Projector / if needed: blackboard or Whiteboard
Literature:	

3. Specialization Program

3.1 1 Compulsory Module

Module name	**Computer Measurement**
Abbrev.	Cmt
Format / SWH	Seminar-type lectures with exercises / 4 SWH
Credit points	5 ECTS
Work requirement	In-class time: 60 hrs, self-study: 90 hrs.
Semester	6
Schedule	Annually
Duration of module	Single semester
Module coordinator	Dr. Jochen Merhof
Instructor(s)	Dr. Jochen Merhof
Language	German
Use in other academic programs	AU, EL and EN
Admission requirements	Eligibility to advance pursuant to §6 Para. 2 SPO
Prerequisites	Fundamentals of electrical measurement technology, basic knowledge of a higher programming language
Qualification objectives / skills	• Students will: Be able to analyze and structure simple tasks in production-integrated measurement and testing technology. • Be able to design and program software concepts for computer-based recording, evaluation and display of measurement values. • Be familiar with the most important hardware interfaces for the coupling of measuring devices and be able to create simple device drivers independently. • Understand the basic problems of digital data acquisition and be able to evaluate the effects on the measurement results. • Know the procedures and the significance of transforming discrete measurement signals into the frequency domain and can implement it programmatically.
Course contents	Introduction to the programming language LabVIEW

	Data types, functions, control structures, measurement data storage and visualization. State machines Instrument interfaces RS232, GPIB, USB and LAN interface, access mechanisms to instruments, instrument command language SCPI. Networked applications ISO/OSI model of communication, TCP/IP protocol stack, local area networks and Internet, server/client architectures. Digitization of measurement data Signal conditioning, sampling and amplitude quantization. Characteristics of analog/digital converters. DAQ systems, quantization noise and aliasing, noise interference. Measurement data processing Fundamentals and application of discrete Fourier transform. Digital filters.
Study / examination grades contributing to final grade	Written examination 90 min.
Other performance tests	Creation of exercise programs
Media:	Classes held in the computer room, projector and blackboard/whiteboard, electronic workbooks, programming and calculation exercises.
Literature:	N. Weichert, M. Wülker: Messtechnik und Messdatenerfassung Oldenbourg 2010 J. Hoffmann, W. Trentmann: Praxis der PC-Messtechnik Hanser 2002 E.O. Brigham: FFT-Anwendungen Oldenbourg 1997 W. Georgi, E. Metin: Einführung in LabVIEW Hanser Fachbuchverlag 2012 B. Mütterlein: Handbuch für die Programmierung mit LabVIEW Spektrum Akademischer Verlag 2007 J. Kring, J. Travis: LabVIEW for Everyone Prentice Hall 2006

Module name	**Electrical Drive and Converter Technology**
Abbrev.	EAS
Format / SWH	Seminar-type lectures (2 SWH), exercise (1 SWH), practical course (1 SWH) / 4 SWH
Credit points	5 ECTS
Work requirement	In-class time: 60 hrs, self-study: 90 hrs.
Semester	5
Schedule	Annually
Duration of module	Single semester
Module coordinator	Dr. Omid Forati Kashani
Instructor(s)	Dr. Omid Forati Kashani
Language	German
Use in other academic programs	AU, EN, EL
Admission requirements	Eligibility to advance pursuant to §6 Para. 2 SPO
Prerequisites	Previous knowledge of the structure, mode of operation and various characteristics of DC as well as asynchronous and synchronous machines from the subject "Electrical Drives and Networks"
Qualification objectives / skills	Students will: Be able to apply the solution methods in drive engineering and explain the mode of operation of the converter topologies as rectifiers, inverters and DC converters for the DC systems as well as three-phase systems. Be able to analyze and solve drive engineering problems in theory and practice and to predict the behavior of the drives with the above-mentioned components. Understand the basics of controlling electric drives and the associated boundary conditions and will be able to apply the basic and fundamental methods.

Course contents	• Mechanical basics (translational and rotational motion, speed converter (gearbox), steady state operation of a drive, stability condition of an operating point) • Drives with DC machines (review of types of DC machines, operating behavior of DC machines, dynamic operation of DC machines) • Drives with rotating field machines (review about the asynchronous and synchronous machine, operating behavior and control of the ASM and SM) • Special machines (operation of the servo motor, the stepper motor, the switched reluctance machine, the brushless DC machine and the linear motor) • Line-commutated converters (two-pulse bridge circuit, B6 circuit and 12-pulse converter) • Self-controlled power converters (operation and control of DC-DC converters, operation and control of DC-DC converters on the mains and machine side, pulse width modulation, operation and control of DC-DC converters) • Fundamentals of controlling electric drives (speed and torque control of DC drives, two-axis theory of three-phase machines and space vector, control of three-phase machines in rotating coordinate system, control of line-side converters, space vector modulation.
Study / examination grades contributing to final grade	Written examination 90 min. and practical study work
Other performance tests	None
Media:	Blackboard, overhead/projector/visualizer/whiteboard Electronically provided working documents and exercises, practical exercises on the test bench in the laboratory
Literature:	- Hans-Christoph Skudelny, Elektrische Antriebe, Verlag der Augustinus Buchhandlung, 1997 - Hans-Christoph Skudelny, Stromrichtertechnik, Verlag der Augustinus Buchhandlung, 1997 - Helmut Späth, Elektrische Maschinen und Stromrichter, Verlag Braun Karlsruhe, 1991 - Rolf Fischer, Elektrische Maschinen, Karl Hanser Verlag Munich, 2011 - Johannes Teigelkötter, Energieeffiziente elektrische Antriebe, Springer Verlag, 2013

Module name	**Hardware Design in Automation Technology**
Abbrev.	HwAu
Format / SWH	Seminar-type lecture (2 SWH), practical course (2 SWH) / 4 SWH
Credit points	5 ECTS
Work requirement	In-class time: 60 hrs, self-study: 90 hrs.
Semester	5
Schedule	Annually
Duration of module	Single semester
Module coordinator	Dr.-Ing. Jochen Merhof
Instructor(s)	Dr.-Ing. Jochen Merhof, Dr.-Ing. Matthäus Brela
Language	German
Use in other academic programs	-
Admission requirements	None
Prerequisites	Basics of digital technology, knowledge of the structure of circuit diagrams, basics of PLC, circuit symbols of electrical components.
Qualification objectives / skills	Subject-related skills: • Ability to name the standards and documents required for the manufacture, operation and maintenance of automation technology machines and systems • Ability to explain the structure and design of circuit diagrams of automation technology, to independently create circuit diagrams with operating equipment, and to control cabinet layout with an electrical CAD system • Ability to assemble the modules of a PLC for process control, regulation, and testing processes • Ability to describe the modules of a PLC for vertical integration of the control level and the architecture for diagnostics during production • Ability to design a safety-related electrical control system and dimension subsystems taking into account failure probabilities

	• Ability to design control-integrated safety solutions using safety I/Os as interfaces to safety-relevant sensors and actuators.
Course contents	• Programming and commissioning of safety controllers • "Safety" components • Introduction to plant and machine automation • Standardization / structure of a control cabinet • Technical drawing, circuit symbols, and labeling • Circuit diagrams and symbols • PLC symbols • PLC design: control technology • PLC design: measurement technology • PLC design: vertical integration • Basics of machine safety • Protection against electric shock, operator interface and labeling • Functional safety and safety-related design
Study / examination grades contributing to final grade	Written exam 60 min. and project work (weight 3:1)
Other performance tests	None
Media:	Projector and blackboard/whiteboard, simulation programs, electronic scripts and working documents, practical exercises.
Literature:	Gerald Zickert, Elektrokonstruktion, Hanser Verlag 2009 Patrick Gehlen, Funktionale Sicherheit von Maschinen, Publicis Corporate Publishing Erlangen 2nd ed. 2010 Paul Heyder, Dieter Lenzkes, Siegfried Rudnik, Elektrische Ausrüstung von Maschinen und maschinellen Anlagen, Erläuterungen zur DIN EN 60204-1, 6th edition 2009 – VDE Verlag Berlin Offenbach

Module name	**Industrial Image Processing**
Abbrev.	IBva
Format / SWH	Seminar-type lectures (2 SWH), practical course (2 SWH) / 4 SWH
Credit points	5 ECTS
Work requirement	In-class time: 60 hrs, self-study: 90 hrs.
Semester	6
Schedule	Annually
Duration of module	Single semester
Module coordinator	Dr. Kolja Kühnlenz
Instructor(s)	Dr. Kolja Kühnlenz
Language	German
Use in other academic programs	-
Admission requirements	Eligibility to advance pursuant to §6 Para. 2 SPO
Prerequisites	Basic knowledge of the following areas required: linear algebra (linear transformations between vector spaces in matrix algebra), analysis (series, differentiation and integration of one and two dimensional functions).
Qualification objectives / skills	After passing the module, students will: Understand the main hardware components of an industrial image processing system, as well as the theory, data structures and implementation of the main algorithms of industrial image processing. Be able to analyze machine vision tasks and use this knowledge and skills to develop image processing applications.

Course contents	The module gives a detailed description of the practical methods and algorithms used to solve machine vision applications. The selection of methods is based on the most common applications of machine vision in automation and robotics: position recognition, shape and dimensional inspection, and object recognition. The main focus of the lecture is the description of the methods and their fundamentals. Examples from practice show the typical applications in which the presented methods are used. In detail, the following topics are covered: - Image acquisition - Image enhancement - Segmentation and feature extraction - Morphology - Edge extraction - Classification - Camera calibration - Stereo reconstruction
Study / examination grades contributing to final grade	Written examination 90 min. and practical study work
Other performance tests	None
Media:	Blackboard, slide presentations, electronically provided working documents, development tools
Literature:	B. Jähne, "Digitale Bildverarbeitung", Springer. C. Demant, B. Streicher-Abel, Bernd, A. Springhoff, "Industrielle Bildverarbeitung", Springer

Module name	**Motion Control**
Abbrev.	MoCo
Format / SWH	Seminar-type lectures (3 SWH), practical course (1 SWH) / 4 SWH
Credit points	5 ECTS
Work requirement	In-class time: 60 hrs, self-study: 90 hrs.
Semester	5
Schedule	Annually
Duration of module	Single semester
Module coordinator	Dr. Matthäus Brela
Instructor(s)	Dr.-Ing. Matthäus Brela, Dr.-Ing. Jochen Merhof
Language	German
Use in other academic programs	AU, EN and EL
Admission requirements	-
Prerequisites	Physical laws of translational and rotational movements, basic knowledge of PLC technology and programming languages, basic knowledge of measurement and control technology.
Qualification objectives / skills	• Students will: Be able to analyze and mathematically describe technical motion sequences. • Be able to reproduce the architecture of motion control and to describe the basic design criteria. • Know the common mechanical devices for the execution of one-dimensional motion processes and be able to distinguish between different positioning tasks. • Know the basic kinematic relationships of mechanically non-coupled and mechanically coupled motion axes and be able to express positions and velocities in different reference systems. • Be able to design position, angle and acceleration measurement systems for motion control.

	• Be able to describe the problem of EMC and be able to calculate resulting errors in the running characteristics. • Know the tasks of synchronization and interpolation of motion axes and the methods and concepts commonly used for this. • Be able to analyze the power flow along a positioning axis and dynamically design simple drive trains. • Understand the concept of cascade control for motion control. • Know the mathematical principles of machine dynamics and be able to apply them. • Know the functionality of the motion control blocks according to PLCopen and be able to program simple positioning tasks with these blocks.
Course contents	• **Kinematic relationships** Basic description of rotational and translational motion sequences, one-dimensional positioning processes, synchronous movements of mechanically uncoupled axes, two-dimensional motion sequences with the help of open or closed kinematic chains, reference coordinate systems and, coordinate transformations, three-dimensional positioning and orientation movements in space by combination of motion axes. • **Dynamic relationships** Power flow and four-quadrant operation, force and torque transmission, masses and moments of inertia, vibration dynamics. • **Control engineering correlations** Current and torque control, velocity control, position control. • **Sensor measurement principle for motion automation** Relative / absolute, position sensors, speed and velocity sensors, acceleration sensors, force and torque sensors. • **Diagnostic systems and safety** Motor data, service data, diagnostic data, scope monitoring, safety functions • **Drive control** Design, start-up, and control of a stepper motor as well as design, start-up, and control of a servo motor. • **Motion control modules according to PLCopen**

	MC-MoveAbsolute, MC-Power, MC-MoveRelative, MC- MoveJog, MC-CamIn, MC-MoveVelocity, and other basic MC blocks. • **Practical experiments** Basic positioning processes Interpolation of axis movements Synchronization of mechanically independent axes
Study / examination grades contributing to final grade	Written examination 90 min. and practical performance certificates
Other performance tests	None
Media	Projector and blackboard/whiteboard, simulation programs, electronic scripts and working documents, practical exercises.
Literature	Kiel E.: Antriebslösungen – Mechatronik für Produktion und Logistik Springer 2007 Groß, Hamann et al.: Technik elektrischer Vorschubantriebe in der Fertigungs- und Automatisierungstechnik, Publicus Corporate Publishing 2012 Heimann, B. et al.: Mechatronik: Komponenten-Methoden-Beispiele Carl Hanser 2007 Weidauer, Jens, Elektrische Antriebstechnik, Grundlagen – Auslegung – Anwendungen – Lösungen. Publicis Corporate Publishing 2008 Weck, M. et al., Werkzeugmaschinen 3 – Mechatronische Systeme, Vorschubantriebe, Prozessdiagnose. Springer Vieweg Verlag, 2006 Reif, K.: Sensoren im Kraftfahrzeug, 3rd edition, Springer Vieweg Verlag, 2016 Brosch, P. F.: Taschenbuch der Antriebstechnik - Messsysteme für E-Antriebe, Carl Hanser Verlag, 2014

Module name	**Control Technology - Specialization Subject**
Abbrev.	Rt
Format / SWH	Seminar-type lectures with exercises / 4 SWH
Credit points	5 ECTS
Work requirement	In-class time: 60h, self-study: 90h
Semester	5
Schedule	Annually
Duration of module	Single semester
Module coordinator	Dr. Kolja Kühnlenz
Instructor(s)	Dr. Kolja Kühnlenz
Language	German
Use in other academic programs	AU, EL and EN
Admission requirements	Eligibility to advance pursuant to §6 Para. 2 SPO
Prerequisites	Basic knowledge of signal and system theory as well as solution methods for linear differential equations in the time and frequency domain
Qualification objectives / skills	• Students will: Be able to distinguish between the basic concepts of control and regulation and will know their essential characteristics. • Be able to analyze the behavior of mechanical, electrical, thermal, and other controlled systems and describe them mathematically in the time and frequency domain. • Know the most important criteria for assessing control loop behavior and the most commonly used continuous controller types. • Know methods for assessing the stability of linear control loops and be able to apply them. • Understand basic design and optimization concepts for linear control loops and apply them to simple examples.

Course contents	Basic structures and methods of control technology System description using differential equations Laplace and Fourier transforms Position curves and Bode diagrams Controlled systems Proportional controlled systems with delay Oscillatory proportional controlled systems Other typical controlled systems Simple linear control loops Basic structure and quality criteria Realization of controllers Control loops with P, PI and PID controllers Guidance and disturbance behavior Stability General stability considerations Hurwitz criterion Control loop design using Bode diagram and root locus curve
Study / examination grades contributing to final grade	Written examination 90 min.
Other performance tests	None
Media:	Blackboard/whiteboard and projector / overhead projector Electronically provided working documents and exercises

Module name	**Robotics**
Abbrev.	Ro
Format / SWH	Seminar-type lectures (3 SWH), exercise (1 SWH) / 4 SWH
Credit points	5 ECTS
Work requirement	In-class time: 60h, self-study: 90h
Semester	5
Schedule	Annually
Duration of module	Single semester
Module coordinator	Dr. Kolja Kühnlenz
Instructor(s)	Dr. Kolja Kühnlenz
Language	German
Use in other academic programs	-
Admission requirements	Eligibility to advance pursuant to §6 Para. 2 SPO
Prerequisites	Knowledge of linear control technology and linear algebra.
Qualification objectives / skills	Subject-related skills: After the course, students will know and understand the basic methods for modeling, analysis, and control of robots. They will be able to apply the methods to different systems of manipulating and mobile robotics. Students will know and understand the operating principles of various sensors in robotics. They will know basic control concepts and be able to analyze them regarding their static and dynamic behavior.
Course contents	- Robot arms and vehicles - Spatial object representation and transformations - Kinematics models of manipulators and robot vehicles (direct and inverse kinematics, differential kinematics, Jacobi matrix, redundancy and singularities, principle of virtual work) - Kinematic path and path planning - Dynamics modeling (Euler-Lagrange model, direct and inverse dynamics)

	- Manipulator control (position, path, force, hybrid control, workspace control vs. joint space control, inverse system technology) - Imaging sensors, image processing techniques, and image-based control - Computation and design exercises
Study / examination grades contributing to final grade	Written examination 90 min.
Other performance tests	None
Media:	Projector and blackboard/whiteboard, electronic scripts and workbooks.
Literature:	J.J. Craig, Introduction to Robotics: Mechanics and Control, Prentice Hall. Husty, M., Karger, A., Sachs, H., Steinhilper, W., Kinematik und Robotik, Springer.

Module name	**Seminar Automation and Robotics**
Abbrev.	AUSem
Format / SWH	Seminar / 4 SWH
Credit points	5 ECTS
Work requirement	In-class time: 30 hrs, self-study: 120 hrs.
Semester	6 or 7
Schedule	Semi-annually
Duration of module	Single semester
Module coordinator	Dr. Kolja Kühnlenz
Instructor(s)	Dr. Omid Forati, Dr. Kolja Kühnlenz, Dr. Matthias Mörz, Dr. Brela
Language	German
Use in other academic programs	-
Admission requirements	Eligibility to advance pursuant to §6 Para. 2 SPO
Prerequisites	None
Qualification objectives / skills	Participants will possess the necessary methodological and interdisciplinary skills to independently prepare, present, and discuss academic seminar papers on more challenging topics in the field of automation and robotics. They will be able to work with scientific literature (research, categorize, prioritize, cite). They will have mastered the required presentation and discussion techniques.

Course contents	Participants work independently on seminar papers on a challenging scientific topic, present and discuss their results. The accompanying paper summarizes the main concepts of the topic and provides an overview of sources. At the beginning of the course, each participant will receive a scientific topic for which he or she will prepare a written paper using self-researched, scientific literature. The results of the work will be presented to the other participants of the seminar in oral form and supported by visual media. The evaluation will also include an assessment on how the participant responds to questions, suggestions, and discussion points about his/her work and presentation, and how he/she participates in the discussion about the work and presentations of the other participants. In this way, students will demonstrate their competence in critically analyzing the work concepts and results of current research projects that are presented. Prior to the start of the seminar, the respective instructor will announce how each performance will be weighted to determine the grade. The lecturers will support students in learning technical and academic skills.
Study / examination grades contributing to final grade	Seminar paper (30 pages) and seminar presentation
Other performance tests	None
Media:	Scientific publications on the respective topic
Literature:	Scientific publications on the respective topic

Module name	**Software Design in Automation Engineering**
Abbrev.	SwAu
Format / SWH	Seminar-type lectures (2 SWH), exercise (1 SWH), practical course (1 SWH) / 4 SWH
Credit points	5 ECTS
Work requirement	In-class time: 60 hrs, self-study: 90 hrs.
Semester	5
Schedule	Annually
Duration of module	Single semester
Module coordinator	Dr. Matthäus Brela
Instructor(s)	Dr. Matthäus Brela
Language	German
Use in other academic programs	AU, EL, EN
Admission requirements	None
Prerequisites	Foundations of digital technology, automata theory, state graphs, control engineering, knowledge of a high-level programming language
Qualification objectives / skills	• Students will learn about the methods and programming techniques of industrial control engineering and be able to solve simple automation tasks independently in the various programming languages of IEC 61131. • Students will be able to structure a control program, use UML modeling languages, program in an object-oriented manner, write reusable code, create libraries, and correct programming errors. • Students will become familiar with the functionality of serial data communication in automation technology and project planning of a bus communication system. • Students will become familiar with the human-machine interface and the methods for projecting and creating user interfaces for industrial controls.

Course contents	• **Control technology** Configuration of controllers, communication in automation technology, field bus systems, distributed systems according to IEC 61499, methods of programming according to IEC61131-3 in structured text. • **Design of visualizations** Operation and monitoring, visualization elements, element linking, control with visualizations, monitoring, analysis, creating simple user interfaces. • **Software design** V-model, use of sequential function chart language for step chain programming, creation of class diagram and its application, creation of state diagram and its application. • **Object-oriented programming** Structure, design, and programming of classes, application of objects, encapsulation, inheritance, derivation, access modifications, constructors, destructors, properties, references, interfaces, virtual and abstract methods, recipe management. • **Reusability** Library creation, error handling, use of pragmas, programming guidelines. • **Practical course:** Communication (protocols), gripper control (visualization), gripper control (sequencing), operational states (state diagram), object-oriented programming (class diagram), libraries (interface), start-up.
Study / examination grades contributing to final grade	Written examination 90 min. and practical performance record
Other performance tests	None
Media:	Projector and blackboard/whiteboard, simulation programs, electronic scripts and working documents, practical exercises.
Literature:	Günther Wellenreuther / Dieter Zastrow: Automatisieren mit SPS, Vieweg Verlag Wiesbaden 4th edition 2008, EAN 978- 3-8348-0231-6 Karl-Heinz John, Michael Tiegelkamp, SPS-Programmierung mit IEC 61131-3, Konzepte und Programmiersprachen, Anforderungen an

	Programmiersysteme, Entscheidungshilfen. VDI-Buch, Springer-Verlag 4th edition 2009, EAN 978-3-6420-0268-7 Eberhardt Grötsch, SPS - Speicherprogrammierbare Steuerungen, Oldenbourg Verlag Munich 5th edition 2004, EAN 978-3-8356-7043-3 Raimond Pigan, Mark Metter (Absolvent unserer Fakultät), Automatisieren mit PROFINET: Industrielle Kommunikation auf Basis von Industrial Ethernet, Publicis Corporate Publishing Erlangen, 2nd edition 2008 Michael Braun, Objektorientiertes Programmieren, Grundlagen, Programmierbeispiele und Softwarekonzept nach IEC61131-3, Publicies Pxelpark Erlangen, 2016, ISBN 978-3-89578-455-2. PLCopen: www.plcopen.org as well as additional books and URL links

3.2 Compulsory Elective Module

Module name	**Advanced Electrical Drives Control**
Abbrev.	AEDC
Format / SWH	Seminar-type lectures (2 SWH), exercise (1 SWH), practical course (1 SWH)
Credit points	5 ECTS
Work requirement	In-class time: 60 hrs, self-study: 90 hrs.
Semester	7
Schedule	Annually
Duration of module	Single semester
Module coordinator	Dr. Omid Forati Kashani
Instructor(s)	Dr. Omid Forati Kashani
Language	German
Use in other academic programs	AU, EN
Admission requirements	Eligibility to advance pursuant to §6 Para. 2 SPO
Prerequisites	Previous knowledge of the subject "Control of Electrical Drives and Power Converters" would be beneficial
Qualification objectives / skills	Students will: Be familiar with the basics of the control of electric drives in continuous-time and discrete-time systems. Be able to describe the control loops of the cascade control by state equations. Be able to determine the control characteristics of the control loops, to analyze them and to design controllers accordingly. Know the modeling of the rotating field machine and control of the drives with rotating field machines without speed sensor.
Course contents	• **General information about state control of electric drives** - State space representation - Continuous state space representation - Discontinuous state space representation • **Space vector and space vector differential equations** - Concept of the space vector - Transformation between phase and space vector quantities (Clarke transformation)

	- Space vector transformation between stationary and rotating reference systems (Park transformation) - Transformation of phase variable differential equations - Back transformation of space vector differential equations • **State models of the asynchronous machine (ASM)** - Continuous state models of the ASM in the stator-fixed and field-synchronous coordinate system - Discrete state models of the ASM • **State models of the permanent magnet excited synchronous full-pole machine (PMSM)** - Continuous state model of the PMSM in the field-synchronous coordinate system - Discrete state model of the PMSM - Similarities between PMSM and ASM as current control system • **Discrete-time description of current control systems** - Fundamental consideration on the basis of an alternating current bridge circuit - Influence of the current acquisition time on the control performance - Influence of the current acquisition time on the mean current value - Influence of the calculation time on the modeling - Generalization to ohmic-inductive and three-phase loads - Current controller design without consideration of a computation time - Symmetrical current controller design with consideration of a calculation time of one sampling interval - Manipulated variable limitation and current setpoint correction - Locking dead time and its compensation • **Speed sensorless control of a drive** - Problems of speed actual value acquisition - Possibilities for the control of rotating field machines without speed sensor - Control of an asynchronous drive without speed sensor - Control of a synchronous drive without rpm sensor
Study / examination grades contributing to final grade	Written examination 90 min. and practical study work
Other performance tests	None

Media:	Blackboard, overhead/projector/visualizer/whiteboard Electronically provided working documents and exercises, practical exercises on the test bench in the laboratory

Literature:	- Dierk Schröder, Elektrische Antriebe-Regelung von Antriebssystemen, Springer Verlag, 2009 - Uwe Nuß, Hochdynamische Regelung elektrischer Antriebe, VDE Verlag GmbH, 2010 - Nguyen Phung Quang und Jörg-Andreas Ditrich, Praxis der feldorientierten Drehstromantriebsregelungen, Expert Verlag, 1999 - Gerhard Pfaff und Christof Meier, Regelung elektrischer Antriebe II-geregelte Gleichstromantriebe, R. Oldenburg Verlag, 1988

Module name	**Digital Signal Transmission**
Abbrev.	DSü
Format / SWH	Seminar-type lectures with exercises / 4 SWH
Credit points	5 ECTS
Work requirement	60 hrs. in-class, 90 hrs. self-study
Semester	6
Schedule	Annually
Duration of module	Single semester
Module coordinator	Dr. Hans-Martin Tröger
Instructor(s)	Dr. Hans-Martin Tröger
Language	German
Use in other academic programs	EL
Admission requirements	Eligibility to advance pursuant to §6 Para. 2 SPO
Prerequisites	Electronics 1B, Electronics 2, Foundations of Electrical Engineering 3
Qualification objectives / skills	Students will learn to analyze digital line-connected transmission systems and to assess their performance. They will understand the structure and functional units of a digital transmission system based on copper cables and optical fibers. They will get an overview of common digital transmission and storage systems and will be able to select them optimally according to the field of application.
Course contents	Introduction to signal theory: Properties of the transmission path, channel capacity, influence of bandwidth and noise, redundancy reduction, error protection The components of a transmission system: Analog-to-digital conversion, line coding, modulation schemes with sinusoidal carriers, demodulation, clock and carrier recovery Pseudorandom codes and spread spectrum technology Modules of optical waveguide technology

	System examples: telephone, digital subscriber line, Ethernet, internal bus systems, optical data storage
Study / examination grades contributing to final grade	Written examination (90 min)
Other performance tests	
Media	Blackboard, overhead/visualizer, projector Work documents and exercises provided in electronic and paper form
Literature	Tietze-Schenk: Halbleiter-Schaltungstechnik, Springer-Verlag, 14th edition 2012 Mäusl-Göbel: Analoge und digitale Modulationsverfahren, Hüthig-Verlag Heidelberg 2002 Martin Werner: Nachrichten-Übertragungstechnik, Vieweg-Verlag 2006

Module name	**Electrical Engineering**
Abbrev.	Emab
Format / SWH	Seminar-type lectures (3 SWH), seminar paper (1 SWH)
Credit points	5 ECTS
Work requirement	In-class time: 60 hrs, self-study: 90 hrs.
Semester	6
Schedule	Annually
Duration of module	Single semester
Module coordinator	Dr. Matthäus Brela
Instructor(s)	Dr. Matthäus Brela
Language	German
Use in other academic programs	AU, EL, EN and mechanical engineering
Admission requirements	None
Prerequisites	Basic knowledge of electrical drive technology
Qualification objectives / skills	Subject-related skills: • Ability to understand the operation and structure of electrical machines • Ability to name and evaluate the steps involved in the manufacture of electrical machines • Ability to reproduce the manufacturing processes necessary for the production • Ability to analyze, evaluate and develop the manufacturing chain of electrical machines holistically
Course contents	• Typical applications / fields of application of electrical machinery manufacturing • Electromagnetic and mechanical fundamentals of electrical machines • Basic motor topologies • Components of the drive train • Manufacturing processes for electrical steel strip, electrical single sheet and sheet stack as well as production-related

	• Fundamentals of loss effects and numerical analysis methods • Production of hard magnetic materials as well as quality assurance and failure analysis • Magnetization and magnet assembly • Winding technology, impregnation, and insulation • Manufacturing of power electronics • Assembly processes and testing technology for quality assurance at the end of the value chain • Electromagnetic actuators, their manufacturing processes, and quality assurance • Recycling of electrical machines and their components • Traceability and I4.0 in electrical engineering • Basics of contactless power transmission and inductive charging systems • Additive manufacturing in electrical engineering • Superconductor electric motors and transfer systems
Study / examination grades contributing to final grade	Written exam 60 min. and seminar paper (weighting 3:1)
Other performance tests	None
Media:	Projector and blackboard/whiteboard, simulation programs, electronic scripts and working documents, practical exercises.
Literature:	Elektrische Servoantriebe, Manfred Schulze, 2008, ISBN 978-3-446-41459-4 Elektrische Antriebssysteme, Ulrich Riefenstahl, 2nd ed., 2006, ISBN 3-8351-0029-7 Elektrische Maschinen, Hans-Ulrich Giersch, 2003, ISBN 3-519-46821-2

Module name	**Empirical Methods in Human-Machine Interaction**
Abbrev.	EMMMI
Format / SWH	Seminar-type lectures (1 SWH), exercise (1 SWH), practical course (2 SWH)
Credit points	5 ECTS
Work requirement	In-class time: 60 hrs, self-study: 90 hrs.
Semester	5, 6 or 7
Schedule	Semi-annually
Duration of module	Single semester
Module coordinator	Dr. Kolja Kühnlenz
Instructor(s)	Dr. Kolja Kühnlenz
Language	German
Use in other academic programs	AU, EE and EL, IF
Admission requirements	Eligibility to advance pursuant to §6 Para. 2 SPO
Prerequisites	None
Qualification objectives / skills	Subject-related skills: After the course, students will be able to independently plan and conduct evaluation studies in human-machine interaction, e.g. for studying acceptance, usability, workload, or user experience. They will also be able to independently plan, carry out, and analyze the measurement data obtained with the help of statistical test procedures. They will be able to use standard tools such as SPSS or R for this purpose. They will be able to take ethical guidelines into account and will be familiar with the requirements for informing test subjects and obtaining informed consent for study participation. They will be able to apply the methods to selected practical experiments.

Course contents	Study design and implementation Ethical aspects and requirements (voluntariness, subject selection, anonymization of data, invasiveness, etc.) Design of participant education and consent form Statistical test procedures (e.g. t-test, ANOVA, Wilcoxon, etc.) SPSS Evaluated psychological test procedures (e.g. personality, well-being, usability, user experience, workload, acceptance, etc.)
Study / examination grades contributing to final grade	Practical proof of performance
Other performance tests	None
Media:	Blackboard, projector, development systems, electronically provided working documents
Literature:	A. Field, "Discovering Statistics Using IBM SPSS Statistics", Sage 2017 Berufsethische Richtlinien des Berufsverbandes Deutscher Psychologinnen und Psychologen e.V. und der Deutschen Gesellschaft für Psychologie e.V. NASA (1986). Nasa Task Load Index (TLX) v. 1.0 Manual A. Weiss, R. Bernhaupt, M. Lankes, M. Tscheligi, "The USUS Evaluation Framework for Human-Robot Interaction", Proc. of AISB 2009.

Module name	**Foundations of Electrical Engineering 3**
Abbrev.	GE3
Format / SWH	Seminar-type lectures (2.5 SWH), exercise (1.5 SWH) / 4 SWH
Credit points	5 ECTS
Work requirement	In-class time: 60 hrs, self-study: 90 hrs.
Semester	5
Schedule	Annually
Duration of module	Single semester
Module coordinator	Dr.-Ing. Matthias Mörz, Dr.-Ing. Alexander Stadler
Instructor(s)	Dr.-Ing. Matthias Mörz, Dr.-Ing. Alexander Stadler
Language	German
Use in other academic programs	AU, EE, EN and EL
Admission requirements	Eligibility to advance pursuant to §6 Para. 2 SPO
Prerequisites	Fundamentals of electrical engineering, signals and systems, mathematics
Qualification objectives / skills	After the course students will be able to: • Describe electrical networks as four-poles with different four-pole representations. • Set up and convert four-pole parameters. • Calculate operating parameters of four-poles. • Interconnect different four-poles and calculate the total four-pole representation. • Interconnect four-poles with three-poles. • Describe and characterize a homogeneous line. • Formulate and solve the telegraph equation. • Describe the behavior of current and voltage along the line. • Describe electromagnetic fields and waves. • State and explain Maxwell's equations.

Course contents	• Four-poles • Complex description of voltage and current • Operating characteristics of four-poles • Four-pole representations • Interconnection of four-poles • Calculation of operating parameters • Conversion of four-pole parameters • Interconnection of four-poles with three poles • Homogeneous line • Voltage and current along the homogeneous line • Vector field, scalar field, field lines • Differential operators • Integral theorems • Electromagnetism • Maxwell's equations
Study / examination grades contributing to final grade	Written examination 120 min.
Other performance tests	None
Media:	Projector and blackboard/whiteboard, simulation programs, electronic scripts and working documents
Literature:	Wilfried Weißgerber: Elektrotechnik für Ingenieure 3, Vieweg + Teubner Eugen Philippow: Grundlagen der Elektrotechnik, Verlag Technik Karl Küpfmüller, Wolfgang Mathis, Albrecht Reibinger: Theoretische Elektrotechnik, Springer Günther Lehner: Elektromagnetische Feldtheorie für Ingenieure und Physiker, Springer Paul A. Tipler, Gene Mosca, Michael Basler, Renate Dohmen: Physik, Spektrum Pascal Leuchtmann: Einführung in die elektromagnetische Feldtheorie, Pearson

Module name	**HDL System Design**
Abbrev.	HDL
Format / SWH	Seminar-type lectures / 4 SWH
Credit points	5 ECTS
Work requirement	In-class time: 60 hrs, self-study: 90 hrs.
Semester	5
Schedule	Annually
Duration of module	Single semester
Module coordinator	Prof. Oliver Engel
Instructor(s)	Prof. Oliver Engel
Language	German
Use in other academic programs	AU, EN and EL, IF
Admission requirements	Eligibility to advance pursuant to §6 Para. 2 SPO
Prerequisites	Foundations of computer engineering, foundations of digital technology
Qualification objectives / skills	1. Students will gain the ability to model digital circuits with respect to structure and behavior. 2. They will master the hardware description language VHDL and will be able to generate synthesizable code from it. 3. Students will learn methods for verifying their own or other people's digital designs and for ensuring their correct operation.
Course contents	VHDL concepts • Structural elements: Entity, architecture, objects • Functional elements: Process, functions, and procedures • Modeling of memory elements and combinatorial circuits • Data structures: scalar and compound data types, arrays, constants, types and subtypes • Structure of libraries Modeling digital hardware:

	• state machines • Memory: RAM, ROM, ring memory • Tristate modeling, interfaces, bus systems • Arithmetic units, filters, bus interfaces • Parallel hardware verification • Testbenches, FileIO elements of synchronous design
Study / examination grades contributing to final grade	Written examination 90 min. and practical study work
Other performance tests	None
Media:	blackboard, projector
Literature:	Jürgen Reichardt, Bernd Schwarz: VHDL-Synthese, Oldenbourg Verlag Paul Molitor, Jörg Ritter: VHDL, Pearson Studium Pong P.Chu: FPGA Prototyping by VHDL Examples, Wiley

Module name	**Practical Course in Digital Signal Transmission**
Abbrev.	DSüP
Format / SWH	Practical course / 2 SWH
Credit points	2.5 ECTS
Work requirement	In-class program: 30 hrs, self-study: 45 hrs.
Semester	7
Schedule	Annually
Duration of module	Single semester
Module coordinator	Dr. Hans-Martin Tröger
Instructor(s)	Dr. Hans-Martin Tröger, Dr. Jochen Jirmann
Language	German
Use in other academic programs	EL
Admission requirements	Eligibility to advance pursuant to §6 Para. 2 SPO
Prerequisites	Electronics 1A&1B, Electronics 2, Fundamentals of Electrical Engineering 3, Digital Signal Transmission
Qualification objectives / skills	Students will learn to analyze digital line-connected transmission systems and to assess their performance. They will understand the structure and functional units of a digital transmission system. They will be able to develop and apply procedures to test transmission quality. They will get an overview of common digital transmission and storage systems and will be able to select them optimally according to the field of application.
Course contents	Introduction to signal theory: Properties of the transmission path, channel capacity, influence of bandwidth and noise, redundancy reduction, error protection The components of a transmission system: Analog/digital conversion Line coding, modulation schemes with sinusoidal carrier demodulation, clock and carrier recovery

	Pseudo-random codes and spread spectrum techniques System examples: telephone and ISDN, Digital Subscriber Line, Ethernet, internal bus systems
Study / examination grades contributing to final grade	Practical course
Other performance tests	None
Media	Blackboard, beamer, overhead projector/visualizer Work documents in electronic and paper form
Literature	Tietze-Schenk: Halbleiter-Schaltungstechnik, Springer-Verlag, 14th edition 2012 Mäusl-Göbel: Analoge und digitale Modulationsverfahren, Hüthig-Verlag Heidelberg Martin Werner: Nachrichten-Übertragungstechnik, Vieweg-Verlag 2006

Module name	**Project Automation Engineering and Robotics 1**
Abbrev.	AuRo1Pr
Format / SWH	Seminar-type lectures (1 SWH), project (3 SWH) / 4 SWH
Credit points	5 ECTS
Work requirement	In-class time: 60 hrs, self-study: 90 hrs.
Semester	6
Schedule	Annually
Duration of module	Single semester
Module coordinator	Dr. Kolja Kühnlenz
Instructor(s)	Dr. Kolja Kühnlenz
Language	German
Use in other academic programs	AU, EN, EL
Admission requirements	Eligibility to advance pursuant to §6 Para. 2 SPO
Prerequisites	None
Qualification objectives / skills	Subject-related skills: After the course, students will have an overview of the current state of research and technology in the respective project-specific area. They will know techniques and tools of project management and be able to plan and execute a project independently. Students will be able to obtain required information through research, develop a concept for solving the project task based on an analysis of the research results, and implement this concept in practice. They will be able to report project progress and results in written reports and media-supported presentations.
Course contents	Systems, components and architectures of automation systems and robots Changing interdisciplinary projects of the subject area with current relevance Independent work on the projects in groups of up to approx. 6 students each

	Research, analysis and concept development Study planning, implementation and evaluation Project management Presentation techniques
Study / examination grades contributing to final grade	Project report and presentation, practical performance test
Other performance tests	None
Media:	Blackboard, projector, development systems, electronically provided working documents
Literature:	Will be provided in the course depending on current project.

Module name	**Project Automation Engineering and Robotics 2**
Abbrev.	AuRo2Pr
Format / SWH	Seminar-type lectures (1 SWH), project (3 SWH) / 4 SWH
Credit points	5 ECTS
Work requirement	In-class time: 60 hrs, self-study: 90 hrs.
Semester	6
Schedule	Annually
Duration of module	Single semester
Module coordinator	Dr. Kolja Kühnlenz
Instructor(s)	Dr. Kolja Kühnlenz
Language	German
Use in other academic programs	AU, EN, EL
Admission requirements	Eligibility to advance pursuant to §6 Para. 2 SPO
Prerequisites	None
Qualification objectives / skills	Subject-related skills: After the course, students will have an overview of the current state of research and technology in the respective project-specific area. They will know techniques and tools of project management and be able to plan and execute a project independently. Students will be able to obtain required information through research, develop a concept for solving the project task based on an analysis of the research results, and implement this concept in practice. They will be able to report project progress and results in written reports and media-supported presentations.

Course contents	Systems, components and architectures of automation systems and robots Changing interdisciplinary projects in the subject area with current relevance Independent work on the projects in groups of up to approx. 6 students each Research, analysis and concept development Study planning, implementation and evaluation Project management Presentation techniques
Study / examination grades contributing to final grade	Project report and presentation, practical performance test
Other performance tests	None
Media:	Blackboard, projector, development systems, electronically provided working documents
Literature:	Will be provided in the course depending on current project.

Module name	**Process Automation**
Abbrev.	Przau
Format / SWH	Seminar-type lectures (1 SWH), practical course (3 SWH) / 4 SWH
Credit points	5 ECTS
Work requirement	In-class time: 60 hrs, self-study: 90 hrs.
Semester	6
Schedule	Annually
Duration of module	Single semester
Module coordinator	Dr. Matthäus Brela
Instructor(s)	Dr.-Ing. Matthäus Brela, Dr.-Ing. Jochen Merhof
Language	German
Use in other academic programs	AU, EN, EL, IF
Admission requirements	None
Prerequisites	Basic knowledge of data processing, basic knowledge of PLC technology, foundation knowledge in measurement technology.
Qualification objectives / skills	• Students will understand the tasks of each layer of the automation pyramid. • They will know the basic differences between process and gauge capability, and gauge acceptance and calibration. • They will be able to independently determine process and gauge capability and differentiate between quality assurance, process optimization, and error diagnosis. • They will be able to design, analyze, and optimize a control system for interrelated processes. • They will understand the role of a process control system (Manufacturing Execution System - MES) • They will be able to reflect on the basic idea of IEC1855 and understand task scheduling in control engineering. • They will be able to describe the reference architecture model Industry 4.0.

	• They will be able to communicate processes using OPC-UA and MQTT protocols.
Course contents	• Introduction to process automation • Automated production plants • Sensors and actuators • Testing processes • Measuring equipment and process capability • Measurement data acquisition and processing • Availability and OEE • Task scheduling • Clock time optimization • Communication in the control technology • Synchronization • OPC and IoT • Computer-aided diagnostics
Study / examination grades contributing to final grade	Examination (60 minutes), practical paper (weight 1:1)
Other performance tests	None
Media:	Projector and blackboard/whiteboard, simulation programs, electronic scripts and working documents, practical exercises.

Literature:	Vogel-Heuser, B.; Bauernhansl, T.; ten Hompel, M.: Handbuch Industrie 4.0, 2nd edition, Springer Vieweg, 2017 Goehner, P.: Agentensysteme in der Automatisierungstechnik, 1st edition, Springer Vieweg, 2013 Reinheimer, S. (publ.): Industrie 4.0 – Herausforderungen, Konzepte und Praxisbeispiele, 1st edition, Springer Vieweg, 2017 Robert Bosch GmbH (publ.): Taschenbuch für Handwerk und Industrie, 6th edition, Senner-Druck, Nürtingen, 2017 Seitz, M.: Speicherprogrammierbare Steuerungen für die Fabrik und Prozessautomation, 4th edition, Carl Hanser Verlag, 2015

	Langmann, R.: Taschenbuch der Automatisierung, 3rd edition, Carl Hanser Verlag, 2017

Module name	**Test Engineering and Backend IC Design**
Abbrev.	
Format / SWH	Seminar-type lectures / excursion: 2 SWH
Credit points	2.5 ECTS
Work requirement	30 hrs. in-class , 45 hrs. self-study
Semester	7
Schedule	Annually
Duration of module	Single semester
Module coordinator	Prof. Oliver Engel
Instructor(s)	Dr. Claus Kuntzsch
Language	German
Use in other academic programs	AU, EL
Admission requirements	
Prerequisites	Knowledge in the field of automation technology and/or semiconductor technology
Qualification objectives / skills	Students will have basic knowledge of semiconductor test engineering and test-friendly design. They will gain a broad overview of test methods and test development and will be able to apply them in a target-oriented manner. Students will learn methods to extend their own or third-party designs with test fixtures, which will allow the shortest possible test cycles with high defect coverage Students will learn the fundamentals for determining the one-time and recurring share of test procedures in production costs.
Course contents	Basic concepts of a test environment • Causes of faults: timing, leakage currents, signal integrity, process variations • Defect definitions, yield, defect coverage, defect models • Test methods: structure, function, self-test, performance Test in production and test-friendly design

	• Feasibility analysis, test concepts • Methods of test-friendly design • Test program development • Special stress tests • Test program optimization • Monitoring and adaptation of test programs • Self-testing in the field Examples of test environments • JTAG, automated test equipment • Scan test with automatic test pattern generation • Hardware in the loop • Test of memory devices Excursion: Semiconductor
Study / examination grades contributing to final grade	Oral examination (30 minutes)
Other performance tests	
Media	Projector, blackboard, excursion
Literature	Script: Summer School Test Engineering and Backend IC Design

Module name	**Control of Electric Drives and Power Converters**
Abbrev.	ReAS
Format / SWH	Seminar-type lectures (2 SWH), exercise (1 SWH), practical course (1 SWH) / 4 SWH
Credit points	5 ECTS
Work requirement	In-class time: 60 hrs, self-study: 90 hrs.
Semester	6
Schedule	Annually
Duration of module	Single semester
Module coordinator	Dr. Omid Forati Kashani
Instructor(s)	Dr. Omid Forati Kashani
Language	German
Use in other academic programs	AU, EN
Admission requirements	Eligibility to advance pursuant to §6 Para. 2 SPO
Prerequisites	Previous knowledge of the structure, mode of operation, and various characteristics of direct current, asynchronous and synchronous machines, and power converters from the subjects "Electrical Drives and Networks" and "Electrical Drives and Power Converters"
Qualification objectives / skills	Students will know the basic control engineering tasks in drive and converter technology and can analyze and process these tasks. They will able to mathematically describe and model the mechanical as well as the electrical subsystem of a drive, consisting of the converter, the drive machine, and the load machine, based on their mode of operation. They will know the dynamic model of the DC machine, the synchronous and the asynchronous machine, and the converter; they will be able to integrate these into control loops, analyze the control loops and design controllers for the drives with these machines according to the quality parameters. Based on the control of the three-phase drives, students will be familiar with the control of the grid-side converter (rectifier) and can design controllers for this converter. They will be able to verify their knowledge by simulations or practical experiments and to

	deepen their knowledge.
Course contents	• Basic tasks in drive and converter technology • Mechanical subsystem (modeling of a rigid compound and a two-mass oscillator, torsional moment of a cylindrical shaft, basic speed control of a rigid compound consisting of the electric drive machine and the load machine, control engineering quality criteria, controller design according to symmetrical and absolute optimum) • Electrical subsystem with the direct current machine (review of the mode of operation of the direct current machine, model formation of the direct current machine) • Control of a drive with a direct current machine (speed and torque or current control of the direct current machine, quality criteria and controller design, mode of operation and control of the brushless direct current machine) • Electrical subsystem with the three-phase machines (operation and modeling of the synchronous and asynchronous machines, space vector, space vector representation of the currents and the voltages of three-phase winding systems, transformation and back transformation between the polar and the Cartesian coordinate system, transformation and back transformation between stationary and rotating coordinate system, active and reactive power with space vector components) • Control of a drive with the three-phase machines (current control in the rotating coordinate system, description of the controlled system, decoupling of the moment-forming and field-forming current control loops) • Control of the synchronous machine (synchronous motor with frequency control, dynamic description of the synchronous machine in the rotor-oriented coordinate system, rotor flux-oriented control, stator flux-oriented control, converter motor) • Control of the asynchronous machine (asynchronous machine with voltage-frequency control, asynchronous motor with stator current-rotor frequency control, model of the asynchronous machine in the rotor-flux-oriented

	coordinate system, rotor flux- or field-oriented control of the asynchronous machine, indirect field orientation, rotor flux determination by voltage or current model, combination of voltage and current models) • Control of the grid-side converter (requirements for the grid-side converter, review of the grid-guided and self-guided converter, control of a self-guided converter, control of a circuit-current-free or circuit-current-affected reverse converter, current control loop of the grid-side self-guided converter in the rotating coordinate system, grid synchronization by PLL, space vector modulation) • Actual value acquisition in the control of electric drives and power converters (current acquisition, voltage acquisition, position or speed acquisition)
Study / examination grades contributing to final grade	Written examination 90 min. and practical study work
Other performance tests	None
Media:	Blackboard, overhead/ projector/ visualizer/ whiteboard Electronically provided working documents and exercises, practical exercises on the test bench in the laboratory
Literature:	- Werner Leonard, Regelung elektrischer Antriebe, Springer Verlag, 2000 - Dirk Schröder, Elektrische Antriebe - Grundlagen, Springer Verlag, 2009 - Dirk Schröder, Elektrische Antriebe - Regelung von Antrieben, Springer Verlag, 1994 - Gerhard Pfaff, Regelung elektrischer Antriebe I – Eigenschaf- ten, Gleichungen und Strukturbilder der Motoren, Oldenburg Verlag, 1991 - Gerhard Pfaff, Regelung elektrische Antriebe II – Geregelte Gleichstromantriebe, Oldenburg Verlag, 1988 - Helmut Späth, Steuerverfahren für Drehstrommaschinen: Theoretische Grundlagen, Springer Verlag, 1983

Module name	**Practical Course in Control Technology**
Abbrev.	RtP
Format / SWH	Practical course / 2 SWH
Credit points	2.5 ECTS
Work requirement	In-class time: 30 hrs, self-study: 45 hrs.
Semester	7
Schedule	Annually
Duration of module	Single semester
Module coordinator	Dr. Kühnlenz
Instructor(s)	Dr. Kühnlenz
Language	German
Use in other academic programs	AU, EL and EE and EN
Admission requirements	Eligibility to advance pursuant to §6 Para. 2 SPO
Prerequisites	Solid foundation in control technology methods and concepts
Qualification objectives / skills	• Students will be able to apply the basic methods of control technology to practical control loops. • They will be able to determine distance parameters, which determine the transmission behavior, using measurement technology. • They will be able to carry out a theoretical and simulation-based controller design. • They will be able to put a control loop into operation for different controlled systems and optimize the controller parameters with regard to control or disturbance behavior. • They will be able to assess the stability of control loops and will know which measures can be taken to improve it.

Course contents	Practical experiments are carried out on the following topics: • Modeling and parameter determination of a DC motor. • Control and disturbance behavior of the current control loop of a DC motor. • Control loop design for an oscillating section with compensation and a dead time section. • Speed control of a motor according to the symmetrical optimum. • Position control as a control loop cascade - speed amplification and following error. • Control of an unstable path - inverse pendulum.
Study / examination grades contributing to final grade	Practical study with experimental work, colloquium
Other performance tests	None
Media:	Electronically provided experimental documents, experimental setups in the laboratory, simulation programs on the computer
Literature:	Schulz G.: Regelungstechnik 1 Oldenbourg 2010 Probst U.: Servoantriebe in der Automatisierungstechnik Vieweg und Teubner 2011

Module name	**Signal Processors**
Abbrev.	Sp
Format / SWH	Seminar-type lectures (2 SWH), practical course (2 SWH) / 4 SWH
Credit points	5 ECTS
Work requirement	In-class time: 60 hrs, self-study: 90 hrs.
Semester	6
Schedule	Annually
Duration of module	Single semester
Module coordinator	Dr. Peter Raab
Instructor(s)	Dr. Peter Raab
Language	German
Use in other academic programs	
Admission requirements	Eligibility to advance pursuant to §6 Para. 2 SPO
Prerequisites	Microcomputer technology, signals, and systems
Qualification objectives / skills	Students will be able to: – Apply basic methods of digital signal processing to various problems (e.g. filters). – Familiarize themselves with advanced modern methods and algorithms and evaluate their performance and complexity. – Understand the mathematical description of standard methods commonly used in DSV and implement them in practical algorithms. – Perform and interpret measurements in the time and frequency domain. – Program simple algorithms for real-time DSV and master the use of the corresponding tools. – Discuss, design, and implement algorithms in the required internship group.

Course contents	**Theory** Fourier transform, interpretation of spectra and spectrograms. Sampling theorem, AD-DA conversion, quantization. Discrete-time systems, Z-transform, transfer function, digital filters, discrete Fourier transform. **Hardware /Software:** DSP, use, structure, memory organization, assembly instructions, data ALU, number formats, arithmetic, format conversion, rounding problems, data conversion (CODEC), real-time applications (signal flow diagrams), interrupt concepts. **Practical course:** Programming of DSV algorithms, tools for filter design (MATLAB, Signal Processing Toolbox), testing of basic principles of signal theory, real-time applications e.g. digital filters (FIR, IIR), spectral analysis (DFT, FFT), delay elements, correlations, use of tools for simulation and emulation, measurement of real-time behavior. The experiments are performed at typical development sites.
Study / examination grades contributing to final grade	Written exam 90 min and prStA (experiments and interviews)
Other performance tests	None
Media	Slides (projector) / blackboard / lab use (evaluation board, SW development environment, debugger)
Literature	Steven W. Smith, The Scientist and Engineer's Guide to Digital Signal Processing Online at http://www.dspguide.com Donald S. Reay, Digital Signal Processing Using the ARM Cortex M4 Wiley 2015 ISBN: 978-1-118-85904-9 D. von Grünigen, Digitale Signalverarbeitung mit einer Einführung in die kontinuierlichen Signale und Systeme, Hanser Verlag, 2008. H. Roderer, A. Pecher, Digitale Signalverarbeitung, Vogel Buchverlag, 2010 M. Werner, Digitale Signalverarbeitung mit MATLAB, Vieweg Verlag, 2003

Module name	**Field Simulation Methods and Applications**
Abbrev.	VAFs
Format / SWH	Seminar-type lectures with integrated exercises (1 SWH), computer practical course (3 SWH) / 4 SWH
Credit points	5/6 ECTS (depending on academic program)
Work requirement	In-class time: 60 hrs, self-study: 90 hrs.
Semester	5-7
Schedule	Semi-annually
Duration of module	Single semester
Module coordinator	Dr.-Ing. Alexander Stadler
Instructor(s)	Dr.-Ing. Alexander Stadler
Language	German
Use in other academic programs	AU, EE, EN, EL
Admission requirements	Eligibility to advance pursuant to §6 Para. 2 SPO
Prerequisites	Mathematics, basics of electrical engineering, basic PC and programming skills
Qualification objectives / skills	• Knowledge: Methods and applications of field simulation to solve practical problems, specialization of field theory basic knowledge, construction of Matlab scripts and functions, pictorial representation of two and three dimensional field quantities, numerical integration over lines, areas and volumes. • Skills: Simplifying practical field problems, creating simple Matlab scripts and functions to evaluate given field approaches, numerically evaluating the approaches on edges and in domains, troubleshooting the program in a structured way by using the Matlab help function and comparing the solutions with known approximation formulas. • Competencies: Analyzing foreign program code and modifying it to solve new problems, specialization of basic field theory knowledge through pictorial representation and numerical evaluation of field quantities, dealing with new, unfamiliar mathematical functions.

Course contents	• Introduction to Matlab • Practical examples and repetition exercises • Programming exercises on electrostatics and magnetostatics, the flow field as well as the law of induction and Maxwell's equations
Study / examination grades contributing to final grade	Written examination (90 min) and seminar lecture (master courses)
Other performance tests	None
Media:	Blackboard lecture, presentation with laptop/beamer, printed exercise script and programming exercises in computer room
Literature:	H. Buchholz, Elektrische und magnetische Potentialfelder, Springer-Verlag, 1957, ISBN-10: 3642480659 G. Lehner, Elektromagnetische Feldtheorie: für Ingenieure und Physiker, Springer-Verlag, 6th edition, 2008, ISBN-10: 3540776818 G. Mrozynski, Elektromagnetische Feldtheorie – Eine Aufgabensammlung, Vieweg+Teubner Verlag, 1st edition, 2003, ISBN-10: 3519004399 M. Abramowitz, I. Stegun, Handbook of Mathematical Functions, Dover Publications Inc., 9th edition, 1970, ISBN-10: 0486612724 J. D. Jackson, Classical Electrodynamics, John Wiley & Sons, 3rd edition, 1998, ISBN-10: 047130932X W. B. Smythe, Static and Dynamic Electricity, Taylor & Francis, 3rd edition, 1989, ISBN-10: 0891169172

4. Thesis Papers

Module name	**Bachelor Thesis**
Format / SWH	BT
Credit points	12 ECTS
Work requirement	Self-study 360 hrs.
Abbrev.	
Semester	7
Schedule	Semi-annually
Duration of module	Single semester
Module coordinator	Dr. Michael Rossner
Instructor(s)	Professors of the E/IF department
Language	German
Use in other academic programs	AU, EE, EN and EL
Admission requirements	Eligibility to advance pursuant to §6 Para. 3 SPO
Prerequisites	None
Qualification objectives / skills	Technical and methodological objectives: Students will be able to independently work on and solve a complex task from their academic program on a scientific basis.
Course contents	Depending on the topic of the Bachelor thesis
Study / examination grades contributing to final grade	Bachelor Thesis
Other performance tests	None
Media:	---
Literature:	H. Balzert, M. Schröder, C. Schäfer: Wissenschaftliches Arbeiten. W3L-Verlag, Dortmund, 2011, Subject-specific literature

Module name	**Bachelor Seminar**
Abbrev.	BcSem
Format / SWH	Seminar / 2 SWH
Credit points	3 ECTS
Work requirement	In-class time: 30 hrs, self-study: 60 hrs.
Semester	7
Schedule	Semi-annually
Duration of module	Single semester
Module coordinator	Dr.-Ing. Matthäus Brela
Instructor(s)	Professors of the FEIF department
Language	German
Use in other academic programs	AU, EE, EN and EL
Admission requirements	Eligibility to advance pursuant to §6 Para. 3 SPO
Prerequisites	None
Qualification objectives / skills	• Students will be able to report on an engineering problem in front of an expert audience. • They will be able to present a task they have worked on themselves in a structured manner and embedded in the scientific context. • They will critically study their own results and be able to represent them in a qualified manner in the discussion. • They will deal critically with the presentation of others and be able to clarify factual questions in a professional dialogue.
Course contents	Depending on the topics of the current bachelor theses
Study / examination grades contributing to final grade	Final presentation on the contents of the student's own Bachelor's thesis of approx. 20 minutes, followed by a discussion
Other performance tests	Participation in 3 other seminar lecture series with 3-5 seminar lectures each
Media	Projector / if needed: blackboard or Whiteboard

Literature	H. Balzert, M. Schröder, C. Schäfer: Wissenschaftliches Arbeiten. W3L-Verlag, Dortmund, 2011