TU Dortmund University
Department of Electrical Engineering and Information Technology

Module Handbook
for the Master's Degree Program
Sustainable Energy Systems

(Examination Regulations 2023)

Updated Version
according to the resolution of the Study Advisory Council dated 02. July 2026
Draft resolution for the Department Council on 22. July 2026

Inhaltsverzeichnis

Structure of the Study Program

1st Semester	2nd Semester	3rd Semester	4th Semester
Design of Sustainable Products & Services 6 CP	Principles of Sustainability 5 CP	Lab Course 6 CP	Master Thesis 30 CP
Energy Economics and Technologies 5 CP	Smart Grids 6 CP	Advanced Seminar 5 CP	
Power System Operation and Stability 8 CP	Power System Economics 5 CP	Industrial Internship 14 CP	
Planning & Operation of Distributed Energy Sources 5 CP	Elective Classes 25 Creditpoints in total15 Creditpoints from the Cataloque Energy Systems		
Elective Classes 5 CP	Elective Classes 15 CP	Elective Classes 5 CP	
Mandatory Courses	Elective Classes	Industrial Internship	Practical Training

The range of elective modules and Lab Courses may vary and is published in the current version of the module handbook. Modules may be discontinued or newly added. There is no entitlement to the offering or delivery of a specific elective module or Lab Course.

Aim of the study program and purpose of the examinations

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Upon successful completion of the Master's degree course in Sustainable Energy Systems, a further professional qualification is acquired. The Master's degree program builds upon the Bachelor's degree program and requires students to have the qualifications acquired in a relevant Bachelor's degree program. The Master's degree program is research-oriented and serves to deepen both advanced technical and methodological-analytical skills. Students acquire knowledge about the future design of the electrical energy system in the areas of sustainability and digitalization for smart grids and markets. In the application areas, graduates have comprehensive knowledge that corresponds to the current state of the art and are familiar with current problems in energy technology and energy system technology in these areas.

Graduates are able to solve current problems in the areas of application independently (Master's thesis) and in a team (industrial placement) using scientific methods. They have gained an insight into an industrial, engineering-related activity through the industrial internship and, in combination with other training elements, have the skills to quickly integrate into an industrial company in the energy sector. The individually specialized knowledge in one of the focus areas enhances students' abilities to develop new concepts within their discipline and implement them, for example, in a Master's thesis linked to a current research topic. Furthermore, graduates are able to process and present scientific literature in such a way that their peers understand the essential concepts and ideas of these works without having read the papers themselves.

The course covers the areas of design, modelling, control and operation of electrical energy systems, taking sustainability perspectives into account. The course also prepares students for decentralized renewable generation, sector coupling with all energy sectors and the associated energy market designs. Graduates will be able to work in these areas of application without a long period of technical training. In addition, they should be able to develop a fundamental understanding of the possibilities for shaping society as well as the social, ethical, economic, political and technical requirements for a sustainable design of energy generation, use and supply in order to derive and implement responsible action in the technical field.

Students should also apply their ability to think and discuss critically in their later participation in social life. Social commitment, responsible behavior and personal development are included as cross-cutting topics in the degree program. The resulting intercultural skills contribute to students' personal development.

The examinations in the Master's degree program are intended to determine whether the candidate is able to independently analyze technical problems from various areas of electrical and energy systems engineering, break them down into suitable subtasks, solve them using scientific methods and knowledge and thereby achieve an overall solution. In addition, the candidate should show that they can develop new scientific methods under supervision.

The in-depth specialist knowledge, skills and methods of the graduates enable them to work in the broad field of the energy transition as well as to pursue a potential doctorate.

Mandatory Courses

Design of Sustainable Products & Services (DSPS) SES-101

Design of Sustainable Products & Services (DSPS)

Rota	Duration	Semester	CP	Attendence	Self Study
WiSe	1 semester	1st semester	6	75 h	105 h

1 **Module Structure**

No.	Course / Element	Type	CP	SWS
1	Design of Sustainable Products & Serv. Lecture	V	3	2
2	Design of Sustainable Products & Serv. Exercise	Ü	1	1
3	Design of Sustainable Products & Serv. Practical Training	P	2	4

2 **Course language**

English

3 **Teaching Content**

Teaching content of elements 1 and 2

1. Design processes for products and services taking into account sustainability criteria
2. Cost accounting for production and operation of products and services
3. Calculation and optimizing of CO2 footprints of products and services
4. Profitability evaluations (net present value calculation, investment decisions)
5. Sustainability as part of the marketing of products (incl. product life cycle, pricing)
6. Organization of companies and projects
7. Business start-up as an option for implementing sustainable product ideas

Teaching content of element 3

1. Computer-based business simulation as an integrated practical course
2. Creation of a business plan for a self-selected, innovative and sustainable product or service offering

Literatur

Kotler, P., Burton, S., Deans, K., Brown, L. & Armstrong, G., 2015. Marketing. Pearson Higher Education.
Berk, J. & DeMarzo, P., 2019, Corporate Finance. (5th ed.). Pearson International.

4 **Competencies**

After completion of the module examination, the students understand the essential business and sustainability aspects of the realization of electrotechnical systems. They will be able to apply suitable methods to take these aspects into account, e.g. to control the sustainable as well as economic use of resources, to evaluate product realization variants and to estimate market potentials.
By completing the module, students should also be able to recognize and incorporate the challenges of today's and future digital societies and thus assume social responsibility. In the field of realization of electrotechnical systems, this includes, for example, raising awareness of socially relevant topics such as age and technology or circular economy and sustainability.

5 **Examinations**

	Module finals: Written exam (120 minutes) (90 % of module grade) and three graded group presentations in Element 3 (the personal contribution must be indicated.) (10 % of module grade) *Course Work:* In Element 2, 50% of the total points for all mandatory exercises must be achieved. The coursework is a prerequisite for taking the module exam.	
6	**Type of Examination** Module Exam	
7	**Participation Requirements** None	
8	**Module Type and Applicability** *Mandatory module* in the Master's degree program Sustainable Energy Systems. *Elective module* in the Master's degree program ETIT (all specializations), with preference given to students from MA SES.	
9	**Module Supervisor** Prof. Dr.-Ing. Christian Wietfeld	**Faculty in charge** Faculty of Electrical Engineering and Information Technology

Energy Economics and Technologies — ETIT-505 (SES-102)

Energy Economics and Technologies

Rota	Duration	Semester	CP	Attendence	Self Study
WiSe	1 Semester	3. Semester	5	35 h	115 h

1 Module Structure

No.	Course / Element	Type	CP	SWS
1	Energy Economics and Technologies Lecture	V		2
2	Energy Economics and Technologies Presentations	Ü		1

2 Course language

Englisch

3 Teaching Content

The course explores the technological, economic, and societal dimensions of energy transi-tions. It introduces the foundations of energy economics, including supply and demand, market structures, externalities, and market failures, and examines their relevance for energy systems. The course covers key energy technologies, transition pathways, and governance approaches, as well as the environmental and social challenges associated with transforming energy pro-duction and consumption. Particular emphasis is placed on the role of data and quantitative analysis in understanding energy systems and informing decision-making. Through case stud-ies and real-world examples, students analyze the interactions between technology, markets, institutions, data, and societal actors in shaping energy transitions.

Literatur

Literature will be provided in the course.

4 Competencies

Upon successful completion of the course, students are able to apply key concepts and analytical tools from energy economics to understand and assess energy systems and energy transitions. They can analyze the technological, economic, environmental, and societal dimensions of energy transition pathways and critically evaluate the opportunities and limitations of different technologies, governance approaches, and market arrangements. Students are able to in-terpret and use energy-related data to support evidence-based analysis and assess contempo-rary challenges in sustainable energy systems.

5 Examinations

Modulprüfung: Written exam.

6 Type of Examination

Modulprüfung

7 Participation Requirements

None

8 Module Type and Applicability

	mandatory modulue in the Master's degree program Sustainable Energy Systems *Elective module* in the master's degree programmes • „Elektrotechnik und Informationstechnik", Profile „Computer Engineering", „Elektrische Energietechnik" • Wirtschaftsingenieurwesen Referenzmodulnummer: MB-405	
9	**Module Supervisor** Prof. Dr. Sibylle Braungardt	**Faculty in charge** Fakultät für Elektrotechnik und Informationstechnik

Power System Operation and Stability					**ETIT-207 (SES-103)**
Rota	**Duration**	**Semester**	**CP**	**Attendence**	**Self Study**
WiSe	1 Semester	1. Semester	8	70 h	170 h

1 **Module Structure**

No.	Course / Element	Type	CP	SWS
1	Power System Operation and Stability Lecture	V		4
2	Power System Operation and Stability Exercise	Ü		2

2 **Course language**

English

3 **Teaching Content**

The course is structured into two main sections:

1. Power System Supervision, Operation and Protection
   - 1.1. Introduction into electrical power systems and its operational tasks
   - 1.2. System architecture of power system control centers
   - 1.3. Algorithms for power system calculation, supervision and operation
   - 1.4. Substation automation and protection architecture
   - 1.5. Power system protection functions and algorithms for short circuit and fault calculation
   - 1.6. Future trends in control centres
2. Power System Stability, Dynamics and Control
   - 2.1. Stability in electrical power systems
   - 2.2. Dynamic power system modelling and simulation
   - 2.3. Small signal and transient rotor angle stability
   - 2.4. Frequency stability
   - 2.5. Voltage stability and voltage control
   - 2.6. Measures to improve stability

Literatur

Power System Stability and Control by Kundur
Power System Analysis and Design by Overbye, Glover, Sarma
Power System Operations by Conejo, Baringo

4 **Competencies**

The transformation of the electrical energy system towards a massive integration of renewable energy resources and sector coupling requires a deep understanding of system operation and stability aspects to guarantee security and reliability.
After successful completion of the module, the students understand the architectural structure of power system supervision, control and protection systems as well as their algorithms for handling the operating conditions of electrical power grids from a security and economic perspective.

	The students are able to analyse the interaction of the supervision, control and protection components for the future transforming energy system. Furthermore, they have knowledge about all kinds of power system stability necessary for planning and operation under consideration of renewable energy and sector coupling. They are able to choose the appropriate models for stability assessment. Based on these, the dynamic behaviour and stability can be calculated and analysed.	
5	**Examinations** *Modulprüfung:* mündliche Prüfung (max. 40 Minuten) oder Klausur (max. 180 Minuten) *Studienleistung:* keine	
6	**Type of Examination** Modulprüfung	
7	**Participation Requirements** Keine	
8	**Module Type and Applicability** *Basismodul* im Masterstudiengang „Elektrotechnik und Informationstechnik“. *Kernmodul* für das Profil „Elektrische Energietechnik“. *Wahlpflichtmodul* im Masterstudiengang Wirtschaftsingenieurwesen, Referenzmodulnummer: MB-411	
9	**Module Supervisor** Prof. Dr.-Ing. Christian Rehtanz	**Faculty in charge** Fakultät für Elektrotechnik und Informationstechnik

Planning and Operation of Distributed Energy Sources — ETIT-503 (SES-104)

Planning and Operation of Distributed Energy Sources

Rota	Duration	Semester	CP	Attendence	Self Study
WiSe	1 Semester	3. Semester	5	35 h	115 h

1 **Module Structure**

No.	Course / Element	Type	CP	SWS
1	Planning and Operation of Distributed Energy Sources Vorlesung	V		2
2	Planning and Operation of Distributed Energy Sources Übung	Ü		1

2 **Course language**

Englisch

3 **Teaching Content**

Electrical energy systems are undergoing a massive transformation towards CO2-neutral technologies for electricity generation. Large-scale power plants are increasingly being replaced by distributed energy conversion plants. This results in new requirements for the operation of distributed resp. decentral supplied electrical energy systems and grids. Within this lecture, different technologies for energy conversion are introduced. In particular, the requirements for system integration, design, grid connection and operation are examined in detail. The lecture is structured into the following topics:

1. Introduction to the implementation of distributed energy systems
2. Technologies of distributed energy conversion and storage
3. Grid connection guidelines and protection of distributed energy conversion systems in low and medium voltage grids
4. Power grid influences and control strategies of converter-based energy conversion
5. Design and evaluation of the economic efficiency of distributed energy conversion systems

Literatur

Renewable energy conversion systems - 1st Edition, Muhammad Kamran & Muhammad Fazal, ISBN: 9780128235980

4 **Competencies**

After successful completion of the module, the students know the process and the effects of the change from a centralised to a decentralised energy supply. They can classify the associated effects and know a selection of (technical control) measures to increase the integration capability of decentralised energy conversion plants in the electrical distribution grids. Furthermore, they are familiar with the different plant technologies for decentralised and regenerative electrical energy conversion. They know the different connection options and their protection concepts according to the common application rules. They are able to plan and operate decentralised energy conversion plants safely, taking into account the economic and technical boundary conditions.

5 **Examinations**

	Module finals: oral (max. 30 minutes) or written exam (max. 90 minutes)	
6	**Type of Examination** Module finals	
7	**Participation Requirements** *Recommended prerequisites:* Knowledge of the fundamentals of energy engineering and electrical power systems	
8	**Module Type and Applicability** *mandatory module* in the master's degree programm Sustainable Energy Systems *Elective module* in the master's degree programs • „Elektrotechnik und Informationstechnik", Profil „Elektrische Energietechnik" • Wirtschaftsingenieurwesen Referenzmodulnummer: MB-420 Kann nur als Zusatzmodul belegt werden, wenn eine Einschreibung in den Masterstudiengang Elektrotechnik und Informationstechnik vorliegt.	
9	**Module Supervisor** Prof. Dr. Sibylle Braungardt	**Faculty in charge** Fakultät für Elektrotechnik und Informationstechnik

Principles of Sustainability

ETIT-413
(SES-105)
(AR-239)

Principles of Sustainability

Rota	Duration	Semester	CP	Attendence	Self Study
SoSe	1 Semester	2nd Semester	5	35 h	115 h

1 **Module Structure**

No.	Course / Element	Type	CP	SWS
1	Principles of Sustainability	V		2
2	Principles of Sustainability	Ü		1

2 **Course language**

English

3 **Teaching Content**

1. What is Sustainability?
2. Legal framework
3. Reporting und Monitoring
4. Our CO2 footprint
5. Circular Economy in the context of energy supply
6. Climate neutral energy supply and demand
7. Sustainable solutions for energy systems (2 lectures)
8. Social Responsibility
9. The Year 2040

Literatur

tbd

4 **Competencies**

After the successful completion, students have the necessary solid knowledge on principles of sustainability. They can put sustainable approaches and solutions into the context of the current legal framework and develop appropriate reporting and monitoring methods. The handling of the different levels of sustainability and their necessary interaction is conveyed based on energy systems. The students can derive the impact of new technology and processes on the path of sustainability.
By completing the module, students should also be able to recognize and incorporate the challenges of today's and future digital societies and thus assume social responsibility. In the field of sustainability, this includes, for example, raising awareness of socially relevant topics such as age and technology or circular economy.

5 **Examinations**

Modulprüfung: oral exam (max. 40 minutes) or written exam (max. 90 minutes)
Studienleistung: tbd

6 **Type of Examination**

Module Exam

7 **Participation Requirements**

	Recommended preconditions: Knowledge about principles of energy technology	
8	**Module Type and Applicability** *Elective Class* in the Master's degree program • „Electrical engineering and Information Technology", Major Fields „Computer Engineering" and „Elektrische Energietechnik" • Automation & Robotics, Field of study:Robotics, Machine Learning, Process Automation *Mandatory module* in the Master's degree program Sustainable Energy Systems.	
9	**Module Supervisor** Hon.Prof. Dr.-Ing. Lars Jendernalik	**Faculty in charge** Faculty of Electrical Engineering and Information Technology

Smart Grids						**ETIT-296 (SES-106) (AR-314)**
Smart Grids						
Rota	**Duration**	**Semester**	**CP**	**Attendence**		**Self Study**
SoSe	1 Semester	2. Semester	6	55 h		125 h

1 **Module Structure**

No.	Course / Element	Type	CP	SWS
1	Smart Grids Lecture	V		3
2	Smart Grids Practical works	P		1

2 **Course language**

Englisch

3 **Teaching Content**

This course will handle the following aspects of the changing electrical energy network:

1. Energy transition towards sustainability
2. New distribution grid users (renewable energy sources, loads and energy storage)
3. Electro-mobility
4. Conventional distribution grids and their transformation for massive renewable integration
5. State estimation
6. Congestion management (Voltage CM and Thermal CM)
7. Protection and control functions
8. Time-series based planning of renewable dominated distribution grids
9. Grid automation and future trends

4 **Competencies**

Renewable energy resources are primarily integrated on the distribution grid level. Therefore, competencies of understanding the integration of renewable energy resources into the distribution grids are key for transforming the energy system towards sustainability. The students successfully finishing the course should be able to

- understand the challenges in today's and future sustainable electrical energy distribution grids
- comprehend the multiple areas of research done in the distribution grids
- develop new solution approaches for energy system transformation towards renewable energy integration based on their acquired knowledge through lectures and practical works

By completing the module, students should also be able to recognize and incorporate the challenges of today's and future digital societies and thus assume social responsibility. In the field of smart grids, this includes, for example, raising awareness of socially relevant topics such as age and technology or data security and digital participation.

5 **Examinations**

	Modulprüfung: oral exam (max. 30 minutes) or written exam (max. 120 minutes)* *Studienleistung:* Active participation in practical works (laboratory tasks, presentations, etc.) is a prerequisite to participate in the examination. * The responsible lecturer will announce the mode of the examination two weeks after the start of the lecture at the very latest.	
6	**Type of Examination** Modulprüfung	
7	**Participation Requirements** *Notwendige Voraussetzungen:* Basic knowledge in Electrical Energy Engineering	
8	**Module Type and Applicability** *Elective* in the Master's degree programs • „Elektrotechnik und Informationstechnik", Studienschwerpunkte „Elektrische Energietechnik" • „Wirtschaftsingenieurwesen", Referenzmodul: MB-324 • Automation & Robotics, Field of study: Process Automation, Robotics, Machine Learning *mandatory module* in the Master's degree program Sustainable Energy Systems.	
9	**Module Supervisor** Dr.-Ing. Ulf Häger	**Faculty in charge** Department of Electrical Engineering and Information Technology

Power System Economics — ETIT-224

Power System Economics

Rota	Duration	Semester	CP	Attendence	Self Study
SoSe	1 Semester	2. Semester	5	35 h	115 h

1 **Module Structure**

No.	Course / Element	Type	CP	SWS
1	Power System Economics Lecture	V		2
2	Power System Economics Exercise	Ü		1

2 **Course language**

Englisch

3 **Teaching Content**

1. Organization of the electricity market and regulatory framework for sustainable energy systems
2. Regulation in electrical power and energy systems
3. Optimization methods in the electricity industry
4. Unit Commitment
5. Grid charges and transmission rights
6. Modeling and simulation of electricity markets and grids with massive integration of renewable energy sources
7. Cross-border electrical energy trading capacities
8. Network congestion management and redispatch optimization
9. Portfolio optimization and risk management
10. Investment in generation and grid capacity

Literatur

D. Kirschen: Fundamentals of Power System Economics, Wiley

4 **Competencies**

After successful completion, students have a sound knowledge of market mechanisms and management strategies in grid-based energy supply. They are able to discuss the technical constraints from the power grids to primarily renewable based energy supply in economic and business contexts. They are able to apply their knowledge in power system economics to further developments in the technical, market and regulatory context towards sustainable, sector-coupled and renewable based energy systems. In addition to the electricity industry in general, the special focus of this lecture is on the electrical network industry.

5 **Examinations**

Module finals: oral (max. 40 minutes) oder written exam (max. 180 minutes)

6 **Type of Examination**

Modulprüfung

7 **Participation Requirements**

Recommended Prerequisites: Knowledge of the fundamentals of energy engineering

8	**Module Type and Applicability** *Mandatory module* in the Master's degree program Sustainable Energy Systems *Elective Module* in the Master's degree programs • „Elektrotechnik und Informationstechnik", Studienschwerpunkt „Elektrische Energietechnik" • Wirtschaftsingenieurwesen, Referenzmodulnummer: MB-419	
9	**Module Supervisor** Prof. Dr.-Ing. Christian Rehtanz	**Faculty in charge** Fakultät für Elektrotechnik und Informationstechnik

Elective Classes- Cataloque Energy Systems

Design and Operation of Electrical Machines — ETIT-220

Design and Operation of Electrical Machines

Rota	Duration	Semester	CP	Attendence	Self Study
WiSe	1 Semester	3rd Semester	5	35 h	115 h

1 **Module Structure**

No.	Course / Element	Type	CP	SWS
1	Design and Operation of Electrical Machines (lecture)	V		2
2	Design and Operation of Electrical Machines (tutorial)	Ü		1
3	Design and Operation of Electrical Machines (course lab)	P		

2 **Course language**

English

3 **Teaching Content**

1. Magnetic fields in electrical machines
2. Design of three-phase windings
3. Modeling of electrical machines depending on the design parameters
4. Materials for electrical machines
5. Rough design of asynchronous machines and synchronous machines

Literatur

Krause: Analysis of Electric Machinery and Drive Systems, IEEE-Wiley Press

4 **Competencies**

After successfully completing the module, students will be able to design, evaluate and modify asynchronous machines and synchronous machines using the appropriate tools. They understand why and how magnetic fields arise within a machine and are able to calculate them. They will be able to classify different types of machines and their areas of application. They will also be familiar with different materials and their areas of application in electrical engineering.
By completing the module, students should also be able to recognize and incorporate the challenges of today's and future digital societies and thus assume social responsibility. In the field of asynchronous and synchronous machines, this includes, for example, raising awareness of socially relevant topics such as age and technology or the circular economy and sustainability.

5 **Examinations**

Modulprüfung: oral exam (max. 40 minutes) or written exam (max. 180 minutes)
Studienleistung: Successful completion of the lab course attempt in part 3.
The course work is a prerequisite for participation in the Module Exam.
The examination can be taken together with the module ETIT 283 (Electrical Drive Systems).

6 **Type of Examination**

	Module examination	
7	**Participation Requirements** *Recommended prerequisites:* Fundamentals of electrical machines.	
8	**Module Type and Applicability** *Elective Class* in the masters degree programmes: • „Elektrotechnik und Informationstechnik“ Profil „Elektrische Energietechnik“ • Sustainable Energy Systems, Energy Systems Cataloque • Wirtschaftsingenieurwesen, Referenzmodul: MB-323	
9	**Module Supervisor** Prof. Dr.-Ing. Martin Pfost	**Faculty in charge** Faculty of Electrical Engineering and Information Technology

Selected Chapters in High Voltage Technology — ETIT-288

Selected Chapters in High Voltage Technology

Rota	Duration	Semester	CP	Attendence	Self Study
SoSe	1 Semester	2. Semester	5	35 h	115 h

1 Module Structure

No.	Course / Element	Type	CP	SWS
1	Selected Chapters in High Voltage Technology (lecture)	V		2
2	Selected Chapters in High Voltage Technology (tutorial)	Ü		1

2 Course language

Englisch

3 Teaching Content

1. Requirements for high-voltage equipment
2. Technology, structure and design
3. Insulation systems for DC
4. Diagnostic methods and technology trends
5. Examples and applications from practice

Literatur

Kuffel: High Voltage Engineering Fundamentals
Küchler: High Voltage Engineering - Fundamentals - Technology - Applications

4 Competencies

Students acquire detailed knowledge of selected operating equipment of power transmission systems. They are familiar with the constructive structure and electrical design and know the technological boundaries which apply for high-voltage devices. The participants are familiar with procedures and measurement methods for quality assurance reasons and diagnostics on high-voltage devices. Examples and applications deepen the knowledge and establish the reference to the operational practice.
By completing the module, students should also be able to recognize and incorporate the challenges of today's and future digital societies and thus assume social responsibility. In the field of high-voltage technology, this includes, for example, raising awareness of socially relevant topics such as age and technology or circular economy and sustainability.

5 Examinations

Module finals: oral (max. 40 minutes) or written exam (max. 180 minutes)
Studienleistung: keine

6 Type of Examination

Modulprüfung

7 Participation Requirements

	Recommended qualifications: Sufficient knowledge in power engineering related topics, which may be acquired e.g. through the participation in the basic module FFIELD- AND NETWORK-BASED MODELLING.	
8	**Module Type and Applicability** *Elective Class* in the masters degree programmes: • „Elektrotechnik und Informationstechnik“ Profil „Elektrische Energietechnik“ • Sustainable Energy Systems, Energy Systems Cataloque • Wirtschaftsingenieurwesen, Referenzmodul: MB-330	
9	**Module Supervisor** Prof. Dr.-Ing. Frank Jenau	**Faculty in charge** Fakultät für Elektrotechnik und Informationstechnik

Automotive Systems					**ETIT-291 (AR-237)**
Automotive Systems					
Rota	**Duration**	**Semester**	**CP**	**Attendence**	**Self Study**
SoSe	1 Semester	2. Semester	5	35 h	115 h

1 **Module Structure**

No.	Course / Element	Type	CP	SWS
1	Automotive Systems Vorlesung	V		2
2	Automotive Systems Übung	Ü		1

2 **Course language**

Englisch

3 **Teaching Content**

1. Vehicle dynamics (tires, longitudinal and lateral dynamics)
2. Actuators in the mechatronic vehicle (steering, braking, and powertrain systems)
3. (Kinematic) vehicle models
4. Sensors measuring vehicle internal quantities (acceleration, yaw rate, steering angle, steering torque, wheel speed, sensor data processing)
5. Vehicle dynamics systems (braking and driving slip control systems)
6. Modern headlight systems and light engineering

Literatur

R. Rajamani: Vehicle Dynamics and Control (Springer)
U. Kiencke, L. Nielsen: Automotive Control Systems (Springer)

4 **Competencies**

The students acquire a profound knowledge of vehicle dynamics systems (dynamics, sensors measuring vehicle dynamics quantities, actuators, models, simulation, control, and optimization). They are able to understand and solve tasks on vehicle dynamics systems with appropriate methods.
By completing the module, students should also be able to recognize and incorporate the challenges of today's and future digital societies and thus assume social responsibility. In the field of vehicle dynamics systems, this includes, for example, raising awareness of socially relevant topics such as age and technology or circular economy and sustainability.

5 **Examinations**

Module finals: oral (max. 40 minutes) oder written exam (max. 180 minutes)

6 **Type of Examination**

Module finals

7 **Participation Requirements**

Recommended Prerequisites: Basic knowledge of mechatronics and mechanics.

8 **Module Type and Applicability**

	Elective Module in the Master's degree progams • „Elektrotechnik und Informationstechnik", Studienschwerpunkt „Robotik und Automotive". • Automation and Robotics, field of study: Robotics, Machine Learning • Sustainable Energy Systems, Energy Systems Cataloque • Wirtschaftsingenieurwesen, Referenzmodulnummer: MB-379	
9	**Module Supervisor** Prof. Dr.-Ing. Prof. h.c. Dr. h.c. Torsten Bertram	**Faculty in charge** Department of Electrical Engineering and Information Technology

Machine Learning in Robotics — ETIT-277 (AR-310)

Machine Learning in Robotics

Rota	Duration	Semester	CP	Attendence	Self Study
SoSe	1 Semester	2. Semester	5	35 h	115 h

1 **Module Structure**

No.	Course / Element	Type	CP	SWS
1	Machine Learning in Robotics Vorlesung	V		2
2	Machine Learning in Robotics Übung	Ü		1

2 **Course language**

English

3 **Teaching Content**

1. Fundamentals of Machine Learning
2. Regression
3. Gaussian Process Regression
4. Artificial Neural Networks
5. Recurrent Neural Networks & Transformers
6. Deep Learning
7. Reinforcement Learning

Literatur

Christopher M. Bishop, Hugh Bishop: Deep Learning: Foundations and Concepts, Springer, 2024

Richard Sutton, Andrew G. Barto: Reinforcement Learning: An Introduction, 2nd edition, MIT Press, 2018

4 **Competencies**

After successful completion of the module, students possess advanced knowledge of the theoretical foundations, methods, and current developments in machine learning. They are able to formally describe, analytically understand, and critically reflect on key model classes such as regression methods, Gaussian process models, neural networks, deep learning approaches (including recurrent architectures and transformers), and reinforcement learning techniques.

Students can abstract complex problem settings and independently select, combine, and implement suitable machine learning approaches. They are capable of designing application-specific models and learning procedures, developing training and optimization strategies, and systematically evaluating and interpreting their performance using appropriate metrics.

	Furthermore, students are able to comparatively analyze different learning methods and make well-founded decisions regarding their application. They can assess the strengths, weaknesses, and limitations of data-driven approaches. Students are also able to independently study scientific literature, critically contextualize current research results, and use them as a basis for advanced development, research, or knowledge-transfer tasks. In line with the qualifications framework at the master's level, students additionally develop the ability to recognize societal, ethical, and legal implications of the use of machine learning and to incorporate these aspects into their technical evaluations.
5	**Examinations** *Modulprüfung:* Written exam *Studienleistung:* keine
6	**Type of Examination** Modulprüfung
7	**Participation Requirements** MA Automation and Robotics: The modules AR-310 (Machine Learning in Robotics) and AR-232 (Machine Learning Methods for Engineers) are mutually exclusive; simultaneous or subsequent enrollment in the other module is not permitted. Students specializing in Robotics are recommended to take AR-310, students specializing in Process Automation are referred to AR-232. Students specializing in Machine Learning may choose either module.
8	**Module Type and Applicability** *Elective Module* in the Master's degree programs • Elektrotechnik und Informationstechnik, Profil: „Robotik und Automotive" • Automation and Robotics, Field of study: Robotics, Machine Learning • Sustainable Energy Systems (Energy System Cataloque) • Wirtschaftsingenieurwesen, Referenzmodulnummer: MB-382
9	**Module Supervisor** apl. Prof. Dr. rer. nat. Frank Hoffmann **Faculty in charge** Department of Electrical Engineering and Information Technology

Electric Drive Systems — ETIT-283

Electric Drive Systems

Rota	Duration	Semester	CP	Attendence	Self Study
WiSe	1 Semester	3rd Semester	5	35 h	115 h

1 Module Structure

No.	Course / Element	Type	CP	SWS
1	Electric Drive Systems (lecture)	V		2
2	Electric Drive Systems (tutorial)	Ü		1
3	Electric Drive Systems (course lab)	P		

2 Course language

English

3 Teaching Content

1. Structure of electric drive systems
2. Principles and modeling of electrical machines
3. Variable speed operation and position sensing methods.
4. Drive inverters and modulation techniques

Literatur

Krause: Analysis of Electric Machinery and Drive Systems, IEEE-Wiley Press

4 Competencies

After successful completion, students will be familiar with the essential properties of the electrical machines used in electric drive systems today and with their application in traction and industry. They are able to mathematically describe and design drive control systems consisting of electrical machines and drive inverters. They successfully apply the common methods for speed control including sensorless operation.
By completing the module, students should also be able to recognize and incorporate the challenges of today's and future digital societies and thus assume social responsibility. In the field of electric drive systems, this includes, for example, raising awareness of socially relevant topics such as age and technology or circular economy and sustainability.

5 Examinations

Modulprüfung: oral exam (max. 40 minutes) or written exam (max. 180 minutes)
Studienleistung: Successful completion of the lab course in part 3.
The course work is a prerequisite for participation in the Module Exam.
The examination can be taken together with the module ETIT 220 (Design and Operation of Electrical Machines).

6 Type of Examination

Module finals

7 Participation Requirements

Recommended prerequisites: Fundamentals of electrical machines.

8 Module Type and Applicability

	Elective Class in the Master's degree programs • „Elektrotechnik und Informationstechnik“ Profil „Elektrische Energietechnik“ und „Robotik und Automotive“ • Sustainable Energy Systems, Energy Systems Cataloque • Wirtschaftsingenieurwesen, Referenzmodul: MB-336	
9	**Module Supervisor** Prof. Dr.-Ing. Martin Pfost	**Faculty in charge** Faculty of Electrical Engineering and Information Technology

Simulation and Testing Methods for Modern Power Systems ETIT-507

Simulation and Testing Methods for Modern Power Systems

Rota	Duration	Semester	CP	Attendence	Self Study
WiSe	1 Semester	2./3. Semester	5	35 h	115 h

1 **Module Structure**

No.	Course / Element	Type	CP	SWS
1	Simulation and Testing Methods for Modern Power Systems Lecture	V		2
2	Simulation and Testing Methods for Modern Power Systems Practical Works	P		1

2 **Course language**

English

3 **Teaching Content**

1. Real-time simulation of power systems
2. Hardware-in-the-loop (HIL) simulation and testing
3. Controller hardware-in-the-loop (CHIL)
4. Power hardware-in-the-loop (PHIL)
5. Electrical design of low-voltage laboratory testbeds
6. Praxis-relevant applications of modern testing

Literatur

N. Watson and J. Arrillaga, Power Systems Electromagnetic Transients Simulation. London: The Institution of Engineering and Technology, 2003.
J. A. Martinez-Velasco, Transient Analysis of Power Systems. Wiley-IEEE Press, 2020.

4 **Competencies**

The aim of the lecture is to deliver comprehensive knowledge on advanced simulation and testing methods for modern power systems, covering both theoretical aspects and practical applications.
After completing the lecture, students can independently design and implement complex simulations and hardware testbeds for testing modern components in power systems (Battery Storage Systems, EV-charging stations, power converters, etc.), apply innovative testing methods, and choose appropriate tools and devices for specific requirements.
By completing the module, students should also be able to recognize and incorporate the challenges of today's and future digital societies and thus assume social responsibility. In the field of simulation and testing methods for modern power systems, this includes, for example, raising awareness of socially relevant topics such as age and technology or circular economy and sustainability.

5 **Examinations**

Module exam: Oral exam (max. 45 minutes) or written exam (max. 120 minutes)
Course assessment: Active participation in practical works (laboratory tasks, presentations, etc.,) is also a prerequisite to participate in the examination

6 **Type of Examination**

	module exam	
7	**Participation Requirements** *Recommended prerequisites:* Basic knowledge in Electrical Energy Engineering and Control Systems	
8	**Module Type and Applicability** *Elective Class* in the Study Programs Sustainable Energy Systems (Energy Systems Catalogue), Electrical engineering and Information Technology (Profile: Elektrische Energietechnik)	
9	**Module Supervisor** Dr.-Ing. Alfio Spina	**Faculty in charge** Faculty of Electrical Engineering and Information Technology

Smart Grid System Engineering: Safety, Security and Resilience — ETIT-508

Smart Grid System Engineering: Safety, Security and Resilience

Rota	Duration	Semester	CP	Attendence	Self Study
WiSe	1 Semester	3. Semester	5	35 h	115 h

1 **Module Structure**

No.	Course / Element	Type	CP	SWS
1	Smart Grid System Engineering: Safety, Security and Resilience Lecture	V		2
2	Smart Grid System Engineering: Safety, Security and Resilience Practical Works	P		1

2 **Course language**

Englisch

3 **Teaching Content**

The course focuses on the interdisciplinary principles and practical methods of system engineering for smart grids, with emphasis on system safety, functional safety, cybersecurity, and resilience. It introduces key concepts such as lifecycle models, SGAM, risk analysis techniques, and relevant safety standards (e.g., IEC 61508, ISO 26262).
A special focus is placed on the role of Digital Twins and Artificial Intelligence in the design and operation of secure and resilient smart grid systems. Through case studies and applied exercises, students gain theoretical and practical skills to develop safe and future-ready energy infrastructures.

Literatur

Leveson, Nancy G. An introduction to system safety engineering. MIT Press, 2023.
Hollnagel, Erik, David D. Woods, and Nancy Leveson. Resilience engineering: Concepts and precepts. Ashgate Publishing, Ltd., 2006.
Gräßler, Iris, and Christian Oleff. Systems engineering. Verstehen und industriell umsetzen. Berlin Heidelberg (2022).

4 **Competencies**

The aim of the lecture is to provide a solid foundation in system safety, functional safety, systems engineering, and resilience in the context of smart grids and critical energy infrastructures.
Students will learn to apply systems engineering principles, conduct hazard and risk analyses, and work with standards such as IEC 61508 and ISO 26262. Through case studies and hands-on exercises, they develop practical skills in designing and validating safe, reliable, and resilient energy systems.
The course also prepares students to engage with emerging technologies such as Digital Twins and Artificial Intelligence, and to critically reflect on their societal and ethical implications in future energy system design.

5 **Examinations**

	Partial achievements: 1. written exam (max. 120 minutes) 2. Team project project in which a practical example is developed and documented using the methods and practices introduced in the lecture and the accompanying practical work. Both partial achievements are graded and contribute equally to the finale grade for the module. *Studienleistungen/course Assessment:* Active participation in practical sessions (e.g., laboratory tasks) is required to be admitted to the written exam.
6	**Type of Examination** Partial Achievement
7	**Participation Requirements** *Mandatory:* Should have Successfully completed either SG or PSOS.
8	**Module Type and Applicability** *Elective Class* in the Master's degree programs • „Elektrotechnik und Informationstechnik“ • Sustainable Energy Systems, Energy Systems Cataloque • Automation and Robotics
9	**Module Supervisor** Apl. Prof. Dr.-Ing. Ulf Häger Dozenten: Dipl.-Ing. Dr.techn. Andreas Strasser, Dipl.-Ing. Thomas Krug **Faculty in charge** Fakultät für Elektrotechnik und Informationstechnik

Components and Systems for Electric Mobility — ETIT-509

Components and Systems for Electric Mobility

Rota	Duration	Semester	CP	Attendence	Self Study
WiSe	1 Semester	3rd Semester	5	45 h	105 h

1 **Module Structure**

No.	Course / Element	Type	CP	SWS
1	Components and Systems for Electric Mobility (lecture)	V		2
2	Components and Systems for Electric Mobility (tutorial)	Ü		1

2 **Course language**

English

3 **Teaching Content**

1. Overview of electromobility and vehicle electronics
2. Energy transmission in electric vehicles
3. Power electronics (basics, DC/DC converters, inverters)
4. Drive technology for electric and hybrid vehicles
5. Battery technologies and battery management
6. Charging technology for electric vehicles
7. Basics of wired data transmission in vehicles
8. Special vehicle bus systems
9. Vehicle development process, testing and diagnostic aspects

Literatur

Slobodan Petrovic: Battery Technology Crash Course
Selected journal and conference papers regarding automotive systems

4 **Competencies**

After successfully completing the module, students will have in-depth knowledge of typical electronic components, energy and data networks for electric vehicles. They will be able to select and parameterize these networks appropriately for a specific vehicle. All important components of drive systems are known and can be integrated into any vehicle class. The in-depth knowledge of battery technologies also allows developments for energy or information technology.
By completing the module, students should also be able to recognize and incorporate the challenges of today's and future digital societies and thus assume social responsibility. In the field of mobile robots, this includes, for example, raising awareness of socially relevant topics such as age and technology or circular economy and sustainability.

5 **Examinations**

Modulprüfung: oral exam (max. 40 minutes) or written exam (max. 180 minutes)

6 **Type of Examination**

Module Exam

7 **Participation Requirements**

	None	
8	**Module Type and Applicability** *Elective Class* in the Master's degree programs • Sustainable Energy Systems • Automation and Robotics • Elektrotechnik und Informationstechnik • Wirtschaftsingenieurswesen, Referenzmodul: MB-408	
9	**Module Supervisor** Prof. Dr.-Ing. Stephan Frei	**Faculty in charge** Faculty of Electrical Engineering and Information Technology

Elective Classes

Local Networks - Communication and Control — ETIT-238

Local Networks - Communication and Control

Rota	Duration	Semester	CP	Attendence	Self Study
SoSe	1 Semester	2. Semester	5	35 h	115 h

1 Module Structure

No.	Course / Element	Type	CP	SWS
1	Local Networks - Communication and Control Vorlesung	V		2
2	Local Networks - Communication and Control Übung	Ü		1

2 Course language

Englisch

3 Teaching Content

1. Basics of networks: technical concepts and applications
2. System examples of wired networks: CAN bus, Ethernet, USB
3. System examples of wireless networks: WLAN, Bluetooth, Zigbee

Literatur

Surgeon: Ethernet
Rech: Wireless LANs
Miller, Bisdikian: Bluetooth Revealed

4 Competencies

After successful completion, the students are able to evaluate the different concepts for local networks with regard to their performance, understand existing standards and build systems as well as assess current further developments of the technology.
By completing the module, students should also be able to recognize and incorporate the challenges of today's and future digital societies and thus assume social responsibility. In the field of local networks, this includes, for example, raising awareness of socially relevant topics such as age and technology or data security and digital participation.

5 Examinations

Modulprüfung: mündliche Prüfung (max. 40 Minuten) oder Klausur (max. 180 Minuten)
Studienleistung: keine

6 Type of Examination

Modulprüfung

7 Participation Requirements

Keine

8 Module Type and Applicability

	Elective Class in the Master's degree programs • „Elektrotechnik und Informationstechnik", Profile „Computer Engineering" sowie „Robotik und Automotive" • "Sustainable Energy Systems", Energy Systems Energy Systems Cataloque • Wirtschaftsingenieurwesen, Referenzmodulnummer: MB-310	
9	**Module Supervisor** Prof. Dr.-Ing. Onur Günlü	**Faculty in charge** Fakultät für Elektrotechnik und Informationstechnik

Mobile Robots					**ETIT-269 (AR-225)**
Mobile Robots					
Rota	**Duration**	**Semester**	**CP**	**Attendence**	**Self Study**
SoSe	1 Semester	2. Semester	5	50 h	100 h

1 **Module Structure**

No.	Course / Element	Type	CP	SWS
1	Mobile Roboter Vorlesung	V		2
2	Mobile Roboter Übung	Ü		2

2 **Course language**

English

3 **Teaching Content**

1. Robot Operating System (ROS2)
2. ROS Toolbox Matlab
3. Sensors, actuators and kinematics of mobile robots
4. Homing and trajectory following
5. Obstacle avoidance
6. Localisation
7. Path planning
8. Navigation
9. Online trajectory optimization
10. Mapping and SLAM

Literatur

selected papers on mobile robotics from journals and conferences

4 **Competencies**

After successfully completing the module, students possess advanced and specialized knowledge as well as practical experience in the field of mobile robotic systems. They understand the theoretical foundations, algorithmic concepts, and system-level relationships of mobile robotics and are able to critically analyze and apply them.
Students are capable of independently analyzing and abstracting complex problems in mobile robotics—particularly in the areas of obstacle avoidance, navigation, localization, path planning, and mapping—and solving them using self-selected methods and algorithms. They can design, implement, parameterize, and systematically evaluate appropriate approaches in ROS and MATLAB under realistic scenarios.
Furthermore, students are able to comparatively assess different approaches in mobile robotics, critically weigh their performance, limitations, and conditions of application, and justify their decisions on a sound technical basis. They can independently study scientific literature, critically contextualize current research results, and use them to address advanced development or research tasks.

	In line with the qualifications framework at the master's level, students also develop the ability to recognize societal, ethical, and sustainability-related implications of the use of mobile robotic systems and to incorporate these aspects into their technical evaluations. This includes, in particular, issues related to human–machine interaction, sustainability, and the responsible deployment of autonomous systems.	
5	**Examinations** *Modulprüfung:* • Successful completion of a practical programming exercise in ROS/Matlab/Python for mobile robot navigation • written exam	
6	**Type of Examination** Modulprüfung	
7	**Participation Requirements** Keine	
8	**Module Type and Applicability** *Elective module* in the Master's degree programs • „Elektrotechnik und Informationstechnik", Studienschwerpunkt „Robotik und Automotive" • Wirtschaftsingenieurwesen, Referenzmodul: MB-313 • Automation & Robotics, Field of study:Robotics, Machine Learning • Sustainable Energy Systems	
9	**Module Supervisor** apl. Prof. Dr. rer. nat. Frank Hoffmann	**Faculty in charge** Department of Electrical Engineering and Information Technology

Remote Sensing					**ETIT-287 (AR-231)**
Remote Sensing					
Rota	**Duration**	**Semester**	**CP**	**Attendence**	**Self Study**
SoSe	1 Semester	2. Semester	5	35 h	115 h

1 **Module Structure**

No.	Course / Element	Type	CP	SWS
1	Remote Sensing Vorlesung	V		2
2	Remote Sensing Übung	Ü		1

2 **Course language**

Englisch

3 **Teaching Content**

1. Sensor systems for capturing aerial and satellite images
2. Properties of aerial and satellite images in different spectral ranges
3. Correction methods for atmospheric and topographic effects
4. Methods for analyzing image data in remote sensing applications
5. Methods for analyzing spectral data in remote sensing applications
6. Orthorectification, georeferencing, and co-registration of aerial and satellite images
7. Classification methods for multi- and hyperspectral image data
8. Practical application examples from current research

Literatur

Schowengerdt, R.A.: Remote Sensing: Models and Methods for Image Processing. 3rd Edition, Academic Press, 2007.

4 **Competencies**

Upon successful completion of the module, students master the fundamentals of remote sensing and the signal and image processing methods required for this purpose. Students can classify tasks for remote sensing systems across different application areas and solve them independently using an independently selected methodology. By completing the module, students should also be empowered to recognize and address the challenges of current and future digital societies, thereby engaging socially. In the field of remote sensing, this includes, for example, raising awareness of socially relevant topics such as aging and technology, as well as data security and digital participation.

5 **Examinations**

Module examination oral exam (max. 40 minutes) or written exam (max. 180 minutes)

*The exact examination modalities will be announced no later than the 2nd session.

6 **Type of Examination**

module finals

7 **Participation Requirements**

	Recommended: Sufficient knowledge of the basics of electrical engineering, signal processing, and image processing.	
8	**Module Type and Applicability** *Elective module* in the Master's degree program • Electrical Engineering and Information Technology, specializations Computer Engineering and Robotics and Automotive • Automation and Robotics • Wirtschaftsingenieurwesen, reference module number: MB-378	
9	**Module Supervisor** Prof. Dr. rer. nat. Christian Wöhler	**Faculty in charge** Fakultät für Elektrotechnik und Informationstechnik

Secure Communications — ETIT-294

Secure Communications

Rota	Duration	Semester	CP	Attendence	Self Study
SoSe	1 Semester	2nd Semester	5	35 h	115 h

1 **Module Structure**

No.	Course / Element	Type	CP	SWS
1	Secure Communications (lecture)	V		2
2	Secure Communications (tutorial)	Ü		1

2 **Course language**

English

3 **Teaching Content**

1. History and Basics of Security
2. Symmetric Cryptography
3. Asymmetric Cryptography
4. Message Authentication Codes and Digital Signatures
5. Post-Quantum Cryptography
6. Secure Wireless Communications

Literature

Trappe: Introduction to Cryptography with Coding Theory
Stallings: Cryptography and Network Security: Principles and Practice
Bloch and Barros: Physical Layer Security: From Information Theory to Security Engineering

4 **Competencies**

This course equips students with the knowledge and skills to identify the challenges of secure and reliable communication systems, to understand, apply, and further develop solutions, and to interpret relevant standards. In addition to the technical aspects, the course enables students to recognize and integrate the broader challenges of current and future digital societies into their professional IT security practice, fostering social responsibility. Within the field of secure and reliable communication technology, this includes, for example, raising awareness of socially relevant issues such as ageing and technology, data security, and digital inclusion.

5 **Examinations**

Modulprüfung: oral exam (max. 30 minutes) or written exam (max. 90 minutes) *
* The exact examination modalities will be announced no later than in the second course session.

6 **Type of Examination**

Module Finals

7 **Participation Requirements**

None

8 **Module Type and Applicability**

	Elective module in the Master's degree programs • Elektrotechnik und Informationstechnik, (specialization Computer Engineering), • Automation and Robotics, (Field of Study: Robotics and Machine Learning) • Sustainable Energy Systems, • Wirtschaftsingenieurwesen (reference module number: MB-363)	
9	**Module Supervisor** Prof. Dr.-Ing. Onur Günlü	**Faculty in charge** Faculty of Electrical Engineering and Information Technology

Mobile Radio Networks 1: Fundamentals and Design Aspects — ETIT-407 (AR-234)

Mobile Radio Networks 1: Fundamentals and Design Aspects

Rota	Duration	Semester	CP	Attendence	Self Study
SoSe	1 Semester	2nd semester	5	35 h	115 h

1 **Module Structure**

No.	Course / Element	Type	CP	SWS
1	Mobile Radio Networks 1: Fundamentals and Design Aspects: Lecture	V		2
2	Mobile Radio Networks 1: Fundamentals and Design Aspects: Lab Course	P		1

2 **Course language**

English

3 **Teaching Content**

1. Market aspects and historical development of mobile communications
2. System aspects (characteristics of propagation, subscriber mobility, resource demand and spectrum allocation, network planning, protocols)
3. TDMA- und CDMA-based cellular networks (2G GSM/GPRS/EDGE, 3G UMTS/HSPA)
4. System architecture of OFDMA-based cellular networks (4G LTE)

The discussion of theoretical content is complemented by practical demonstrations and by case studies on ongoing research and business aspects of mobile radio networks.

Literatur

Literature (respective latest version)

Walke, B.: Mobile Radio Networks, Wiley.
Rappaport, Theodore S.: Wireless communications: principles and practice. Prentice Hall.
Dahlmann, E.; Parkvall, S.; Sköld, J.: 4G: LTE/LTE-Advanced for Mobile Broadband, Academic Press.

4 **Competencies**

After successful completion of the module, students understand the system architectures, protocols, dimensioning and operation of mobile radio networks. Students are able to evaluate the possibilities and challenges of using wireless networks in different deployment environments and fields of application, and to make a technically sound selection. In this way, they acquire the competence to attend more advanced courses or to study more advanced topics for themselves.

By completing the module, students should also be able to recognize and incorporate the challenges of today's and future digital societies and thus assume social responsibility. In the field of mobile radio networks, this includes, for example, raising awareness of socially relevant topics such as age and technology or data security and digital participation.

5 **Examinations**

	Modulprüfung: oral exam (max. 45 minutes) or written exam (max. 180 minutes)* *Studienleistung:* successful completion of lab tasks tasks required for registration to the exam. *The exact examination modalities will be announced by the 2nd lecture week at the latest.	
6	**Type of Examination** Module exam	
7	**Participation Requirements** None. *Recommended prerequisites:* Basic knowledge of digital communications and electromagnetic wave propagation	
8	**Module Type and Applicability** *Elective Course* in Master Degree Program • „Electrical Engineering and Information Technology“, profile „Computer Engineering“. • „Automation & Robotics”, recommended field of study „Cognitive Systems” • „Wirtschaftsingenieurswesen“, module reference number: MB-392. • „Applied Computer Science” and „Computer Science”, both with application subject „Electrical Engineering”, module reference number: INF-MSc-AF-ET-230.	
9	**Module Supervisor** Prof. Dr.-Ing. Christian Wietfeld	**Faculty in charge** Faculty of Electrical Engineering and Information Technology

Mobile Radio Networks 2: Advanced Network Concepts — ETIT-408 (AR-235)

Mobile Radio Networks 2: Advanced Network Concepts

Rota	Duration	Semester	CP	Attendence	Self Study
SoSe	1 Semester	2nd semester	5	35 h	115 h

1 **Module Structure**

No.	Course / Element	Type	CP	SWS
1	Mobile Radio Networks 2: Advanced Network Concepts: Lecture	V		2
2	Mobile Radio Networks 2: Advanced Network Concepts: Lab Course	P		1

2 **Course language**

English

3 **Teaching Content**

1. Local radio networks (WLAN/Wi-Fi, WPAN, Mesh, DECT)
2. Wireless Internet of Things networks (Low Power Wide Area Networks, Cellular-IoT)
3. Advanced features of 4G and 5G networks (Carrier Aggregation, Device-to-Device, Network Slicing, Beamforming, Ultra Reliable and Low Latency Communications)
4. Satellite networks, Aerial Wireless Networks
5. Future mobile network concepts for 5G-Advanced and 6G (e.g. mmWave/THz spectrum, Reflective Intelligent Surfaces, Integration of Artificial Intelligence)

The discussion of theoretical content is complemented by practical demonstrations and by case studies on ongoing research and business aspects of mobile radio networks.

Literatur

Literature (respective latest version)

Liberg, Olof, et al.: Cellular Internet of Things: From Massive Deployments to Critical 5G Applications. Academic Press.

Dahlmann, E.; Parkvall, S.; Sköld, J.: 4G: LTE/LTE-Advanced for Mobile Broadband, Academic Press.

P. Marsch, A. Osseiran, J.F. Monserrat, 5G Mobile and Wireless Communications Technology, Cambridge University Press.

4 **Competencies**

Upon successful completion of the module, students understand advanced and upcoming mobile radio network concepts and terminology which enables them to characterize research-related challenges of integrating the considered features, assess the feasibility, and to develop design solutions according to design goals. Students further deepen their knowledge base on specific network designs for particular fields of application, and to make a technically sound selection.

By completing the module, students should also be able to recognize and incorporate the challenges of today's and future digital societies and thus assume social responsibility. In the field of advanced mobile radio networks, this includes, for example, raising awareness of socially relevant topics such as age and technology or data security and digital participation.

5	**Examinations** *Modulprüfung:* oral exam (max. 45 minutes) or written exam (max. 180 minutes)* *Studienleistung:* successful completion of lab tasks for the registration to the exam. *The exact examination modalities will be announced by the 2nd lecture week at the latest.
6	**Type of Examination** Module exam
7	**Participation Requirements** None. *Recommended prerequisites:* Basic knowledge of mobile radio networks
8	**Module Type and Applicability** *Elective Course* in Master Degree Programs • „Electrical Engineering and Information Technology“, Profile „Computer Engineering“. • „Automation & Robotics”, recommended field of study „Cognitive Systems”. • „Sustainable Energy Systems” • „Wirtschaftsingenieurswesen“ (module reference number: MB-393) • „Applied Computer Science” and „Computer Science”, both with application subject „Electrical Engineering”, module reference number: INF-MSc-AF-ET-263.
9	**Module Supervisor** Prof. Dr.-Ing. Christian Wietfeld **Faculty in charge** Faculty of Electrical Engineering and Information Technology

Modeling and Control of Robotic Manipulators — ETIT-244 (AR-106)

Modeling and Control of Robotic Manipulators

Rota	Duration	Semester	CP	Attendence	Self Study
WiSe	1 Semester	3. Semester	5	35 h	115 h

1 **Module Structure**

No.	Course / Element	Type	CP	SWS
1	Modeling and Control of Robotic Manipulators Vorlesung	V		2
2	Modeling and Control of Robotic Manipulators Übung	Ü		1

2 **Course language**

Englisch

3 **Teaching Content**

1. Spatial transformations
2. Forward and inverse kinematics
3. Differential kinematics and inverse kinematics algorithms
4. Dynamics
5. Motion control
6. Robotics System Toolbox and Robot Operating System (ROS)

Literatur

Siciliano et al., Foundations of Robotics, Springer

4 **Competencies**

Upon successful completion of the module, students possess advanced and specialized knowledge in the modeling, analysis, and control of robotic systems. They understand the mathematical and systems-theoretic foundations of spatial transformations, kinematic and dynamic models, as well as modern motion and control methods, and are able to formally describe and critically analyze these concepts.

Students are able to independently abstract complex problems in robotics, select appropriate modeling and control approaches, and methodically design, implement, and evaluate them. They can apply forward, inverse, and differential kinematics as well as dynamic models to systematically develop and analyze control strategies for robotic systems. In doing so, they make use of suitable tools and software environments such as the Robotics System Toolbox and the Robot Operating System (ROS).

Furthermore, students are capable of comparatively assessing different modeling and control approaches, evaluating their underlying assumptions, performance, and limitations, and making well-founded technical decisions. They can independently study scientific literature, classify current methods, and use them as a basis for further development, research, or application-oriented tasks.

In line with the qualifications framework at the master's level, students additionally develop the ability to work independently, critically reflect on complex technical relationships, and clearly justify and communicate their results.

5	**Examinations** *Modulprüfung:* written exam (max. 180 minutes)	
6	**Type of Examination** Modulprüfung	
7	**Participation Requirements** Keine	
8	**Module Type and Applicability** *Wahlpflichtmodul* in den Masterstudiengängen • „Elektrotechnik und Informationstechnik“, Profil „Robotik und Automotive“ • Sustainable Energy Systems • Wirtschaftsingenieurwesen Referenzmodulnummer: MB-312 Kann nur als Zusatzmodul belegt werden, wenn eine Einschreibung in den Masterstudiengang Elektrotechnik und Informationstechnik vorliegt.	
9	**Module Supervisor** apl. Prof. Dr. rer. nat. Frank Hoffmann	**Faculty in charge** Fakultät für Elektrotechnik und Informationstechnik

Automated Driving					**ETIT-504 (AR-321)**
Automated Driving					
Rota	**Duration**	**Semester**	**CP**	**Attendence**	**Self Study**
WiSe	1 Semester	3. Semester	5	35 h	115 h

1 **Module Structure**

No.	Course / Element	Type	CP	SWS
1	Automated Driving Vorlesung	V		2
2	Automated Driving Übung	Ü		1

2 **Course language**

Englisch

3 **Teaching Content**

1. Exteroceptive sensors (camera, radar, lidar, ultrasonic, sensor fusion)
2. Conditional, highly, and fully automated driving
   2.1. Situation analysis and interaction-aware trajectory prediction
   2.2. Trajectory planning and coupled prediction and planning
   2.3. Control concepts to follow a planned trajectory
3. Machine learning in automated driving
4. Driver monitoring and hand-over models

Literatur

I. Goodfellow, Y. Bengio, A. Courville: Deep Learning (MIT Press)
D. Forsyth, J. Ponce (Ed.): Computer Vision: A Modern Approach (Prentice Hall)
selected papers on automated driving, robotics, and deep learning

4 **Competencies**

The students acquire a profound knowledge of automated driving systems. They are able to understand and solve tasks on perception, prediction, planning, control, and driver modelling with appropriate methods.
By completing the module, students should also be able to recognize and incorporate the challenges of today's and future digital societies and thus assume social responsibility. In the field of automated driving systems, this includes, for example, raising awareness of socially relevant topics such as age and technology or circular economy and sustainability.

5 **Examinations**

Module finals: oral (max. 40 minutes) oder written exam (max. 180 minutes)
Coursework: none

6 **Type of Examination**

Module finals

7 **Participation Requirements**

Recommended Prerequisites: Basic knowledge of mechatronics and mechanics; lecture: Automotive Systems.

8 **Module Type and Applicability**

	Wahlpflichtmodul in den Masterstudiengängen • Elektrotechnik und Informationstechnik, Profil „Robotik und Automotive“ • Automation and Robotics, field of study: Robotics, Machine Learning • Sustainable Energy Systems • Wirtschaftsingenieurwesen, Referenzmodulnummer: MB-396 This course can only be taken as a Zusatzmodul if the student is enrolled a master’s program.	
9	**Module Supervisor** Prof. Dr.-Ing. Prof. h.c. Dr. h.c. Torsten Bertram	**Faculty in charge** Department of Electrical Engineering and Information Technology

Introduction to the German Language and Communication ETIT-512

Introduction to the German Language and Communication

Rota	Duration	Semester	CP	Attendence	Self Study
SoSe	2 Semester	1st & 2nd Semester	5	45 h	45 h

1 **Module Structure**

No.	Course / Element	Type	CP	SWS
1	Language Class (German as a foreign Language) A1.1	S		4
2	Language Class (German as a foreign language) A1.2	S		4

2 **Course language**

German

3 **Teaching Content**

Students acquire capabilities to communicate private information in past and present, to name and ask for professions or study subjects and to query simple information on job offers. Furthermore, skills to express commands or giving guidance on an entry level, to make appointments or communicate emergencies, e.g. being sick, via phone, are trained. Further skill to be trained are listed but not limited to

1. understand and phrase phone messages
2. ask for explanations and express polite support requests or instructions
3. query or explain a route to a target
4. read or write invitations and express good wishes
5. name pieces of clothing and body parts

To complete the module, students must pass both elements. Students must complete Element 1 before they can start Element 2.

Literatur

4 **Competencies**

Successful completion of this module will grant knowledge of German as a foreign language and will have gained or enhanced their knowledge of German culture. Besides enhancing the general scope of education knowledge of the German language will help students enter the German job market.

5 **Examinations**

Modulprüfung: To successfully complete the module, a graded coursework* must be completed in each module element. The overall module grade is composed of the two graded coursework, each contributing 50% to the final grade.
*The exact examination modalities will be announced by the 2nd course at the latest.

6 **Type of Examination**

Module Exam

7 **Participation Requirements**

	Necessary requirement: This module can only be attended by students with little or no knowledge of German. Students whose native language is German, who have German language skills at level A2 or above, or who completed their school or university education at a German-speaking institution are not eligible to participate.	
8	**Module Type and Applicability** *Elective Class* in the Master's degree program Sustainable Energy Systems.	
9	**Module Supervisor**	**Faculty in charge** Faculty of Electrical Engineering and Information Technology

Modern Coding Systems and Applications for SES — ETIT-513

Modern Coding Systems and Applications for SES

Rota	Duration	Semester	CP	Attendence	Self Study
WiSe	1 Semester	1. Semester	5	70 h	80 h

1 **Module Structure**

No.	Course / Element	Type	CP	SWS
1	Modern Coding Systems and Applications Lecture	V		4
2	Modern Coding Systems and Applications Tutorial	Ü		2

2 **Course language**

Englisch

3 **Teaching Content**

1. Basic models for modern coding systems
2. Principles of digital coding: encoding/decoding concepts, performance metrics, and simulation-based evaluation
3. Modern codes: Polar codes, LDPC codes, iterative decoding
4. Analog coding for over-the-air function computation
5. Machine learning-based coding methods: autoencoder-based communication systems, neural decoders, and data-driven performance optimization
6. Coding for modern storage and distributed systems: DNA storage, coded distributed computing, and network coding concepts
7. Coding for trustworthy and efficient networked applications: federated learning, privacy-aware distributed learning, and selected blockchain/network-coding applications
8. Modelling, simulation, and validation of coding systems: abstraction levels, performance-complexity trade-offs, benchmark scenarios, and interpretation of simulation results
9. Selected recent research papers on modern coding applications, including student presentations and moderated technical discussions

Literature

Richardson and Urbanke: Modern Coding Theory
MacKay: Information Theory, Inference, and Learning Algorithms
Selected recent articles from journals and conferences on modern coding systems and applications

4 **Competencies**

	This course equips students with the knowledge and skills to model, simulate, and evaluate modern coding systems for data storage, distributed computation, communication, networked learning, and cyber-physical infrastructures. Students learn to identify suitable source, channel, storage, computation, learning, and network models, to understand and apply digital, analog, and learning-based coding methods, and to assess their performance using simulation-based and analytical tools. After successful completion of the module, students are able to compare modern coding approaches with respect to reliability, efficiency, latency, complexity, scalability, and implementation constraints. They can interpret recent research papers and transfer the presented methods to emerging application areas such as wireless communication systems, DNA storage, over-the-air computation, federated learning, network coding, trustworthy distributed systems, smart grids, distributed energy infrastructures, autonomous robotic systems, and industrial automation networks. In addition to the technical aspects, the course enables students to recognize and integrate the broader challenges of current and future digital societies into their professional practice, fostering social responsibility. Within the field of modern coding systems and their applications, this includes, for example, raising awareness of socially relevant issues such as data security, privacy, digital inclusion, sustainable communication and storage infrastructures, reliable information processing in networked systems, and resource-efficient digitalization of energy, automation, and robotic systems.	
5	**Examinations** *Module exam:* oral examination (max. 40 minutes) or written examination (max. 180 minutes).* *The exact examination modalities will be announced no later than in the second course session.	
6	**Type of Examination** Module examination	
7	**Participation Requirements** *Prerequisites:* None	
8	**Module Type and Applicability** *Elective module* for the Master's degree program "Sustainable Energy Systems"	
9	**Module Supervisor** Prof. Dr.-Ing. Onur Günlü	**Faculty in charge** Fakultät für Elektrotechnik und Informationstechnik

Lab Courses

Lab Course						**ETIT-20P**
Lab Course						
Rota	**Duration**	**Semester**	**CP**	**Attendence**		**Self Study**
WiSe & SoSe	1 Semester each	3rdSemester	6	90 h		90 h
1	**Module Structure**					
	No.	**Course / Element**		**Type**	**CP**	**SWS**
	1	Lab Course 1		P	3	45
	2	Lab Course 2		P	3	45
2	**Course language**					
	English					
3	**Teaching Content**					
	The students complete 2 compulsory elective internships from the range of courses offered by the faculty. If internships with a total of 6 LP are available, only one internship is to be completed. The exact descriptions and information on the internships can be found in the following internship descriptions 1-18 or on the Internet.					
4	**Competencies**					
	After successful completion of the course, students are able to discuss different perspectives on an engineering problem and explain their own views. and to explain their own views. The students are able to structure larger tasks during a group work phase and to derive meaningful work packages. Furthermore, the students understand the methodological approaches and procedures in the context of scientific work in engineering and can apply these to different problems. By completing the module, students should also be able to recognize and incorporate the challenges of today's and future digital societies and thus assume social responsibility.					
5	**Examinations**					
	Studienleistung: The examination requirements are deposited in the respective internship descriptions.					
6	**Type of Examination**					
	Partial achievements					
7	**Participation Requirements**					
	The participation requirements are listed in the respective internship descriptions. The number of participants is limited. Admission to participation is in accordance with § 9 of the examination regulations.					
8	**Module Type and Applicability**					
9	**Module Supervisor**		**Faculty in charge**			
	Dean of the Faculty of Electrical Engineering and Information Technology		Faculty of Electrical Engineering and Information Technology			

Electromagnetic Field Theory Simulation — ETIT-211

Electromagnetic Field Theory Simulation

Rota	Duration	Semester	CP	Attendence	Self Study
SoSe (Block)	2 Wochen	2. Semester	3	60 h	30 h

1 **Module Structure**

No.	Course / Element	Type	CP	SWS
1	Praktikumsversuche	P	3	

2 **Course language**

Englisch

3 **Teaching Content**

1. introduction to the functioning and procedure of numerical field calculation programmes.
2. theory of the numerical methods of field calculation on which the programmes are based
3. transferring electrical engineering problems into suitable calculation models
4. utilisation of symmetry properties, special features of discretisation (calculation accuracy/ duration), types of boundary conditions and degrees of freedom
5. simulation and calculation of selected problems (two-dimensional, rotationally symmetrical) for time-dependent and independent fields, respectively.
6. functional verification and comparison of numerical solutions with analytical calculation results (if possible)
7. export of obtained simulation results for further numerical and graphical processing.

Literatur

Kost: Numerische Methoden in der Berechnung elektromagnetischer Felder

4 **Competencies**

After successful completion of the practical course, the students have acquired basic knowledge about the possibilities and limitations of field calculation programs. They are able to transfer real field-theoretical problems into a calculable arrangement. They also have knowledge that enables them to reduce the computational effort to a necessary level through suitable measures and to assess the quality of a simulation result obtained in this way.

By completing the module, students should also be able to recognize and incorporate the challenges of today's and future digital societies and thus assume social responsibility. In the field of field theoretical simulation, this includes, for example, raising awareness of socially relevant topics such as age and technology or data security and digital participation.

5 **Examinations**

Studienleistung: Erfolgreiche Bearbeitung von 70% der Praktikumsaufgaben

6 **Type of Examination**

Teilleistungen

7 **Participation Requirements**

	Recommended Prerequisites: Knowledge of the fundamentals of electrical engineering; basic mathematical knowledge of numerical computation The number of participants is limited. Admission to the course is granted in accordance with § 9 of the examination regulations.	
8	**Module Type and Applicability** *Lab/Praktikum* in the Master's degree program • „Elektrotechnik und Informationstechnik“ • Automation and Robotics • Sustainable Energy Systems	
9	**Module Supervisor** Prof. Dr.-Ing. Frank Jenau	**Faculty in charge** Fakultät für Elektrotechnik und Informationstechnik

Simulative performance evaluation of communication networks — ETIT - 214

Simulative performance evaluation of communication networks

Rota	Duration	Semester	CP	Attendence	Self Study
WiSe (Block)	2 Weeks	2. Semester	3	48 h	42 h

1 Module Structure

No.	Course / Element	Type	CP	SWS
1	Simulative performance evaluation of communication networks	P	3	-

2 Course language

English

3 Teaching Content

1. develop the required basics of OMNeT++
   1.1. Simulation setup
   1.2. Module and simulation definition/declaration
   1.3. Simulation of simple communication networks
2. modelling of system properties
   2.1. Modelling of communication protocols (ISO/OSI)
   2.2. Consideration of mobility aspects on OMNeT++
   2.3. Modelling and consideration of communication channel properties
   2.4. Implementation of complete system scenarios
3. evaluation and optimisation of complex communication systems
   3.1. Simulation of dynamic communication networks
   3.2. Tools for statistical analysis
   3.3. Validation of obtained results

Literatur

Peterson, Davie: Computer Networks, 4th Edition;
Sinclair: Simulation of Computer Systems and Computer Networks

4 Competencies

After successful completion of the practical course, the students have a sound knowledge of the performance evaluation and dimensioning of communication systems by means of event-driven simulation. In addition to the actual functions of the OMNeT++ simulation environment, this also includes the implementation and highly accurate simulative realisation of protocol-based processes in communication systems. The graduates of this practical course will be able to abstract even complex networking scenarios and map them realistically in the OMNeT++ simulation environment. Furthermore, the results obtained in this way can be processed accordingly and used for performance evaluation or optimisation based on aspects relevant to communication technology.

	By completing the module, students should also be able to recognize and incorporate the challenges of today's and future digital societies and thus assume social responsibility. In the field of simulative performance evaluation of communication networks, this includes, for example, raising awareness of socially relevant topics such as age and technology or data security and digital participation	
5	**Examinations** Successful completion of at least 80% of the tasks set. The module concludes with graded partial assessments.	
6	**Type of Examination** Accumulated Grade	
7	**Participation Requirements** *Prerequisites:* The number of participants is limited. Admission to participation is in accordance with § 9 of the examination regulations	
8	**Module Type and Applicability** *Lab* in the master's degree programs • Automation & Robotics • Elektrotechnik und Informationstechnik • Sustainable Energy Systems	
9	**Module Supervisor** Prof. Dr.-Ing. Christian Wietfeld	**Faculty in charge** Department of Electrical Engineering and Information Technology

Simulation and control of robot systems — ETIT - 216

Simulation and control of robot systems

Rota	Duration	Semester	CP	Attendence	Self Study
WiSe	1 Semester		3	48 h	42 h

1 Module Structure

No.	Course / Element	Type	CP	SWS
1	Simulation and control of robot systems	P	3	4

2 Course language

English

3 Teaching Content

1. basic competence: Matlab, Simulink, Robotic Toolbox, Virtual Reality
2. attempt: Modelling, kinematics and dynamics
3. experiment: path planning and control
4. experiment: image-based control

Literatur

Bode: Systeme der Regelungstechnik mit MATLAB und Simulink;
Angermann, Beuschel, Rau, Wohlfarth: Matlab – Simulink – Stateflow: Grundlagen, Toolboxen, Beispiele;
Siciliano, Sciavicco, Villani, Oriolo: Robotics – Modelling, Planning and Control;

4 Competencies

After successful completion of the practical course, the students master the essential practical basics and methods for modelling and simulating robotic systems. The students are able to classify tasks in robotics and solve them independently; they have in-depth knowledge of the control and regulation of robotic manipulators through practical application. By completing the module, students should also be able to recognize and incorporate the challenges of today's and future digital societies and thus assume social responsibility. In the field of modelling and simulation of robot systems, this includes, for example, raising awareness of socially relevant topics such as age and technology or circular economy and sustainability.

5 Examinations

Studienleistung: The supervisor checks the completion of all subtasks and the protocol during the event.

6 Type of Examination

Accumulated Grade

7 Participation Requirements

Prerequisites: The number of participants is limited. Admission to participation is in accordance with § 9 of the examination regulations.

8 Module Type and Applicability

	Lab in the master's degree programs • Automation & Robotics • Elektrotechnik und Informationstechnik • Sustainable Energy Systems	
9	**Module Supervisor** Prof. Dr.-Ing. Prof. h.c. Dr. h.c. Torsten Bertram	**Faculty in charge** Department of Electrical Engineering and Information Technology

Programming Reconfigurable Hardware — ETIT-350

Programming Reconfigurable Hardware

Rota	Duration	Semester	CP	Attendence	Self Study
SoSe	1 Semester	3rd Semester	3	45 h	45 h

1 **Module Structure**

No.	Course / Element	Type	CP	SWS
1	Lab	P	3	4

2 **Course language**

Englisch

3 **Teaching Content**

1. Design of hardware circuits and logic on FPGAs
2. Usage of design and EDA tools
3. Practical work with FPGA platforms
4. VHDL programming

Literatur

„Digital Electronics with DIGILENT BASYS 2 & 3 FPGA Boards“, Andrzej J. Gapinski, Lap Lambert Academic Publishing, 2018, ISBN 9786139929764

4 **Competencies**

By attending this course, students will learn how to work with current FPGA Architectures and Boards. The fundamentals in the usage of tools and programming VHDL will be shown. In multiple practical lessons, VHDL and Xilinx Vivado will be used to implement hardware designs for different tasks. The students will implement practical exercises on a Basys3 Development Board with an Artix 7 FPGA.
By completing the module, students should also be able to recognize and incorporate the challenges of today’s and future digital societies and thus assume social responsibility. In the field of reconfigurable hardware, this includes, for example, raising awareness of socially relevant topics such as age and technology or circular economy and sustainability.

5 **Examinations**

Successful completion of 70% of the internship tasks.
The module concludes with graded partial assessments.

6 **Type of Examination**

Teilleistungen

7 **Participation Requirements**

Recommended prerequisite:
Basic knowledge of computer architectures
Basic knowledge of VHDL programming
The number of participants is limited. Admission to participation is in accordance with § 9 of the examination regulations.

8 **Module Type and Applicability**

	Elective Lab in the Master's degree program Sustainable Energy Systems. *Praktikum* im Masterstudiengang „Elektrotechnik und Informationstechnik“	
9	**Module Supervisor** Prof. Dr.-Ing. Stephan Frei	**Faculty in charge** Faculty of Electrical Engineering and Information Technology

Control system operation for electrical power grids — ETIT - 351

Control system operation for electrical power grids

Rota	Duration	Semester	CP	Attendence	Self Study
SoSe	1 Semester		3	45 h	45 h

1 **Module Structure**

No.	Course / Element	Type	CP	SWS
1	Control system operation for electrical power grids	P	3	4

2 **Course language**

English

3 **Teaching Content**

Control systems are the human-machine interface between the electrical energy transmission system and the actions necessary to keep the system stable and safe throughout the day. Uncertainties due to grid users and volatile renewable energies as well as disturbances in the grid and generation must be monitored and handled appropriately.
Teaching Content

1. Introduction to the control centre operation of electrical transmission networks
2. operation of a realistic control system
3. carrying out network operation management for regular operating situations on the control centre simulator
4. carrying out network operations for disturbed operating situations on the control centre simulator

Literatur

Kundur: Power System Stability and Control

4 **Competencies**

After successful completion of the practical course, the students have acquired basic knowledge of control system operation for electrical power grids. They are able to guide a power grid through various normal and disturbed operating situations on the control centre simulator and add/remove grid components to the grid in the case of grid expansion or optimization. This creates a deep understanding of the real control system in practice.
Today's possibilities are taught during the practical course using a realistic control system software with which the grid operation management personnel are also trained for practice and tried out using operating situations.
By completing the module, students should also be able to recognize and incorporate the challenges of today's and future digital societies and thus assume social responsibility. In the field of control system operation for electrical power grids, this includes, for example, raising awareness of socially relevant topics such as age and technology or circular economy and sustainability.

5 **Examinations**

Completion of all subtasks and preparation of a protocol.
The module concludes with graded partial assessments.

6 **Type of Examination**

	Accumulated Grade	
7	**Participation Requirements** *Recommended prerequisites:* Knowledge of the basics of electrical power engineering, knowledge of information systems for grid operation management. *Prerequisites:* The number of participants is limited. Admission to participation is in accordance with § 9 of the examination regulations.	
8	**Module Type and Applicability** *Lab* in the master's degree programs • Automation & Robotics • Elektrotechnik und Informationstechnik • Sustainable Energy Systems	
9	**Module Supervisor** Dr.-Ing. Ulf Häger	**Faculty in charge** Department of Electrical Engineering and Information Technology

High Performance Computing in Python — ETIT-354

High Performance Computing in Python

Rota	Duration	Semester	CP	Attendence	Self Study
SoSe (Block)	2 weeks	2nd semester	3	48 h	42 h

1 **Module Structure**

No.	Course / Element	Type	CP	SWS
1	Lab	P	3	90

2 **Course language**

English

3 **Teaching Content**

1. Concepts for evaluating the performance of implemented algorithms (profiling)
2. Computationally efficient algorithms and application of multiprocessing for speed improvement
3. Distributed programming for clusters or networked computers utilizing Pyro
4. Connection of existing systems via the application of Numba, PyPy, f2py
5. NumPy for fast computations
6. Cython for speed improvements
7. Speeding up an existing loop using OpenMP by building modules for parallelization
8. Exemplary implementation and evaluation of an algorithm for the design of quantum devices

Literatur

Gorelick, Ozswald: High Performance Python

4 **Competencies**

Students gain practical knowledge of developing procedures for the implementation of high-performance computing algorithms. They learn about the practical behavior and how the performance characteristics of high-performance computing systems can be evaluated as well as what the limits of a hardware-oriented simulation are. Furthermore, students will have gained the essentials of the open-source software framework Python for the realization of high-performance computing in engineering applications. They will be able to speed up algorithms for fast computation.
By completing the module, students should also be able to recognize and incorporate the challenges of today's and future digital societies and thus take on social responsibility. In the area of high-performance computing in Python, this includes, for example, raising awareness of socially relevant topics such as age and technology or circular economy and sustainability.

5 **Examinations**

The Supervisor checks the completion and the reports of all subtasks during the course. The module concludes with graded partial assessments.

6 **Type of Examination**

Teilleistungen

7 **Participation Requirements**

	Recommended prerequisites: Basic knowledge in programming. The number of participants is limited. Admission to participation takes place according to § 9 of the examination regulations.	
8	**Module Type and Applicability** *Lab* as part of the MSc programs „Electrical and Information Engineering“ and “Sustainable Energy Systems”	
9	**Module Supervisor** apl. Prof. Dr.-Ing. Dirk Schulz	**Faculty in charge** Fakultät für Elektrotechnik und Informationstechnik

Advanced Battery and Fuel Cell Technology for Sustainable Energy Systems — ETIT-355

Advanced Battery and Fuel Cell Technology for Sustainable Energy Systems

Rota	Duration	Semester	CP	Attendence	Self Study
SoSe (Block)	2 Weeks (Block event)	3rd Semester	6	90 h	90 h

1 **Module Structure**

No.	Course / Element	Type	CP	SWS
1	Introduction into Chemistry for Sustainable Energy Systems	V		40
2	Safety Training			10
3	Lab	P		40

2 **Course language**

English

3 **Teaching Content**

Introduction into Chemistry for Sustainable Energy Systems

1. Redox-Reactions, Mass- and Charge Transport in Liquids and Solid-State Materials, Cyclic Voltammetry
2. Thermodynamics and Kinetics, Catalytic Processes, Photocatalysis
3. Battery-Technology
4. Fuel Cells

Safety Training

- Safety Practices in Laboratories and in Electrochemistry

Lab

- Selected Experiments on Catalysis, Batteries and Fuel Cells

Literature

S. Petrovic - Battery Technology Crash Course, Springer, 2021
S. Petrovic - Electrochemistry Crash Course for Engineers, Springer, 2021
K. Kreuer - Fuel Cells, Springer, 2013

4 **Competencies**

5 **Examinations**

Studienleistung: Successful completion of 70% of the internship tasks

6 **Type of Examination**

Partial achievements

7 **Participation Requirements**

Recommended prerequisites: Knowledge of the basics of Electrical Engineering, Basic Mathematical Knowledge of Numerical Calculation.
The number of participants is limited. Admission to participation is in accordance with § 9 of the examination regulations.

8	**Module Type and Applicability** *Elective Lab* in the Master's degree programs • Elektrotechnik und Informationstechnik • Sustainable Energy Systems	
9	**Module Supervisor** Prof. Dr.-Ing. Stefan Tappertzhofen	**Faculty in charge** Faculty of Electrical Engineering and Information Technology

Smart Grids Lab						**ETIT-356**
Smart Grids Lab						
Rota	**Duration**	**Semester**	**CP**	**Attendence**		**Self Study**
SoSe (Block)	1 Semester	2nd Semester	3	45 h		45 h

1	**Module Structure**				
	No.	**Course / Element**	**Type**	**CP**	**SWS**
	1	Lab	P	3	4
2	**Course language** English				
3	**Teaching Content** Through a series of guided experiments and project-based testing scenarios, students will: 1. Design and implement test setups for component- and system-level validation 2. Deploy advanced testing methods based on hardware-in-the-loop 3. Use of modern instrumentation for accurate measurement of electrical parameters 4. Apply software tools for real-time data acquisition, signal analysis and visualization 5. Conduct testing and validation aligned with specific use cases and operational scenarios 6. Analyze the dynamic performance and control characteristics of electrical apparatus 7. Integrate electrical assets to enable coordinated operation and flexible management 8. Implement automated control systems driven by real-time data and performance metrics				
4	**Competencies** This laboratory course offers hands-on experience with the testing and evaluation of modern electrical technologies, including regulating transformers, battery energy storage systems, electric vehicle charging stations, inverters and further electrical resources of modern power systems. By completing this module, students will gain practical skills in component- and system-level testing, measurement, data acquisition and component interoperability. Emphasis is placed on understanding physical behavior under real-world operating conditions, using modern tools for data acquisition and visualization, and conducting comprehensive performance assessments of integrated power systems.				
5	**Examinations** *Studienleistung:* Fulfillment of all assigned tasks and submission of a technical report.				
6	**Type of Examination** Teilleistungen				
7	**Participation Requirements** *Required prerequisites:* successful completion of the module “Simulation and Testing Methods for Modern Power System” (STMMPS) *Recommended prerequisites:* participation on the module “Smart Grids” (SG) The number of participants is limited. Admission to participation is in accordance with § 9 of the examination regulations.				
8	**Module Type and Applicability**				

	Elective Class in the Study Programs “Sustainable Energy Systems”, as well as „Electrical engineering and Information Technology“, major field of study „Elektrische Energietechnik“	
9	**Module Supervisor** Dr.-Ing. Alfio Spina	**Faculty in charge** Faculty of Electrical Engineering and Information Technology

Digital Transmission Lab — ETIT-358

Digital Transmission Lab

Rota	Duration	Semester	CP	Attendence	Self Study
WiSe (Block)	2 weeks, by arrangement	2. Semester	3	48 h	42 h

1 **Module Structure**

No.	Course / Element	Type	CP	SWS
1	Digital Transmission Lab	P		90

2 **Course language**

English/Deutsch (as needed)

3 **Teaching Content**

1. Concepts for modelling and simulation: modulation and channel coding methods, simulation outputs/results, and their implementation using hardware components and measurement equipment.
2. Design of transmission methods based on predefined hardware modules and investigation of transmission techniques such as ASK, QAM, FSK, OFDM, and CDMA.
3. Interpretation of results based on various performance indicators, such as bit error rate, eye diagram, spectrum, and bandwidth efficiency.
4. Behaviour of transmission links under different channel models, including AWGN channels and multipath propagation.
5. Modelling and simulation of the impact of practical impairments, such as carrier estimation errors and nonlinearities.
6. Behaviour of transmission systems when channel coding methods are used, including simple block and convolutional codes.
7. Measurement and modelling of radio channels.
8. Simulation of selected transmission system examples.
9. Exemplary implementation of transmission technology algorithms in hardware.

Literatur

Proakis: Digital Communications
Moon: Error Correction Coding
Sklar: Digital Communications: Fundamentals and Applications.

4 **Competencies**

Students acquire practical knowledge of the methodology used in the development of digital transmission systems. They learn how such systems can be modelled and what limitations apply to hardware-oriented simulation. Furthermore, based on a modular system consisting of hardware components in combination with measurement equipment, students become familiar with the practical behaviour and performance characteristics of digital transmission systems and compare these with theoretical analyses. They gain knowledge of the practical implementation of essential system elements and components.

	By completing the module, students should also be enabled to recognise and take into account the challenges of present and future digital societies to assume social responsibility. In the field of digital transmission systems, this includes, for example, raising awareness of socially relevant topics such as ageing and technology, data security, and digital participation.	
5	**Examinations** *Studienleistung:* The lab supervisor checks the completion of all subtasks and the report during the sessions.	
6	**Type of Examination** Teilleistungen	
7	**Participation Requirements** *Recommended prerequisites:* Basic knowledge of digital transmission technology, although the course content will include a quick recap of relevant topics. The number of participants is limited to 12. Continuous attendance is mandatory. Admission to participation is granted in accordance with Section 9 of the examination regulations.	
8	**Module Type and Applicability** *Laboratory* in the Master's programmes "Electrical Engineering and Information Technology", "Automation & Robotics", and "Sustainable Energy Systems"	
9	**Module Supervisor** Prof. Dr.-Ing. Onur Günlü	**Faculty in charge** Fakultät für Elektrotechnik und Informationstechnik

GIS-Lab for Sustainable Energy Systems — ETIT-514

GIS-Lab for Sustainable Energy Systems

Rota	Duration	Semester	CP	Attendence	Self Study
WiSe	1 Semester	3rd Semester	3	45 hours	45 hours

1 **Module Structure**

No.	Course / Element	Type	CP	SWS
1	Lab	P	3	4

2 **Course language**

English

3 **Teaching Content**

Geographic Information Systems (GIS) have become essential tools for analyzing spatial aspects of energy systems and sustainability challenges. This laboratory course introduces students to the fundamentals of spatial data and GIS-based analysis, with a particular focus on applications in sustainable energy systems.

The course begins with an introduction to geographic data, including spatial data types, coordinate systems, data quality, and common sources of geospatial information. Students are then introduced to the open-source GIS software QGIS and learn how to visualize, manage, and analyze spatial datasets.

Building on these foundations, students develop and conduct an independent GIS-based research project on a topic related to sustainable energy systems. Students formulate a research question, identify and acquire suitable datasets, perform spatial analyses, interpret their results, and communicate their findings in a presentation.

The course emphasizes hands-on learning, critical assessment of data sources, reproducible workflows, and the application of GIS methods to real-world sustainability and energy challenges.

Literatur

QGIS Training manual: `https://docs.qgis.org/3.44/en/docs/training_manual/index.html`

4 **Competencies**

After successful completion of the course, students will be able to:

Knowledge

- Understand the fundamental concepts of Geographic Information Systems (GIS), including spatial data models, coordinate reference systems, metadata, and data quality.
- Describe the role of geospatial analysis in addressing challenges related to sustainable energy systems.
- Identify relevant sources of geospatial data and understand their opportunities and limitations for scientific analysis.

	Skills • Apply GIS methods and tools using QGIS to visualize, manage, process, and analyze spatial datasets. • Acquire, evaluate, and integrate geospatial data from multiple sources. • Formulate a research question suitable for GIS-based investigation in the field of sustainable energy systems. • Design and conduct an independent spatial analysis project, selecting appropriate methods and workflows. **Competence** • Independently plan and execute a GIS-based research project from problem formulation to reporting. • Critically assess the quality, uncertainty, and limitations of geospatial data and analytical methods. • Demonstrate self-directed learning by acquiring new data sources, methods, and technical skills required for the project.
5	**Examinations** *Module Exam:* Presentation of project results* * The exact examination modalities will be announced by the 2nd course at the latest.
6	**Type of Examination** Module examination
7	**Participation Requirements** *Recommended prerequisites:* None
8	**Module Type and Applicability** *Elective Lab* in the Master's degree program Sustainable Energy Systems.
9	**Module Supervisor** Prof. Dr. Sibylle Braungardt **Faculty in charge** Faculty of Electrical Engineering and Information Technology

Industrial Internship, Advanced Seminar, and Master Thesis

Industrial Internship — ETIT-282

Industrial Internship

Rota	Duration	Semester	CP	Attendence	Self Study
none	12 weeks	3rd Semester	14	420 h	

1 **Module Structure**

No.	Course / Element	Type	CP	SWS
1	Industrial Internship	P	14	420 h

2 **Course language**

English or German

3 **Teaching Content**

The industrial internship takes place in the following areas:

1. Research and development,
2. Project planning, design, manufacture, assembly, testing and commissioning,
3. Operation and maintenance,
4. Marketing, sales, operational organisation, management and training

The Internship Office of the Department of Electrical Engineering and Information Technology advises each student on the selection of an internship company and the implementation of the internship. The advice and support includes, in particular, the curricular fit of the internship area offered by the internship company with the student's chosen major. The professional assessment and evaluation of the industrial internship is carried out for each student by a university lecturer of the faculty.

4 **Competencies**

After successful completion of the industrial internship, the students have an insight into the operational processes and organisation in industry as well as into the social structures of companies. Furthermore, they know typical engineering tasks in research and development and/or in production and operation. Finally, they have knowledge of practical procedures in industrial production and/or the use of modern technologies in electrical power engineering.
By completing the module, students should also be able to recognize and incorporate the challenges of today's and future digital societies and thus assume social responsibility.

5 **Examinations**

Modulprüfung: A report book must be prepared on the internship. The evaluation of success and performance is based on the submitted reports (submitted electronically as PDF) and the internship certificate of the company.
The requirements for an internship report can be found in the faculty's internship guidelines.

6 **Type of Examination**

7 **Participation Requirements**

Recommended knowledge: Knowledge to perform engineering related activities

8 **Module Type and Applicability**

	Industrial internship in the Master's degree program Sustainable Energy Systems	
9	**Module Supervisor** Prof. Dr.-Ing. Ulf Häger	**Faculty in charge** Faculty of Electrical Engineering and Information Technology

Advanced Seminar (Oberseminar): Scientific presentation — ETIT-281

Advanced Seminar (Oberseminar): Scientific presentation

Rota	Duration	Semester	CP	Attendence	Self Study
WiSe & SoSe	1 Semester	3rd Semester	5	55 h	95 h

1 **Module Structure**

No.	Course / Element	Type	CP	SWS
1	Course Scientific Work: Paper presentation	V		2
2	Posterpresentation	S		2

2 **Course language**

English

3 **Teaching Content**

The aim of this module is to deepen and expand students' knowledge and skills in dealing with and presenting scientific literature. The aim is to prepare them for presenting their own Master's thesis.
The lecture covers the following topics:

1. research and selection
2. classification and elaboration
3. summary of contents

The aim is to develop a comprehensive understanding of how to handle scientific literature.
The poster presentation aims to apply theoretical knowledge to practical situations. This includes:

1. elaboration of the content of scientific papers
2. poster presentation of scientific work to an expert audience
3. discussion of scientific theses and results with an expert audience

The presentation topics will be assigned during the lecture.
Active participation in five final presentations will enable students to reflect on the challenges of the 'presentation' format. This will enable them to anticipate possible difficulties that may arise when presenting their own thesis.

4 **Competencies**

Students can familiarise themselves with a scientific publication and are able to place the publication in the overall context of the respective field. They can present the content of the publication to an expert audience, answer questions about the content of this publication and discuss the conclusions from this publication with an expert audience. To this end, they are proficient in the presentation techniques customary in scientific lectures. In addition, they can participate in the discussion about the contents of a scientific lecture from their subject area.
By completing the module, students should also be able to recognize and incorporate the challenges of today's and future digital societies and thus take on social responsibility.

5 **Examinations**

	Modulprüfung: The student's final poster presentation is the Module Exam. *Studienleistung:* In addition, the student must actively participate in at least five final presentations by other students (e.g. on BA- or MA-Theses) as coursework.	
6	**Type of Examination** Module Exam	
7	**Participation Requirements**	
8	**Module Type and Applicability** *Mandatory Module* in the Master's degree program Sustainable Energy Systems.	
9	**Module Supervisor** Prof. Dr. (Cantab) Stefan Palzer	**Faculty in charge** Faculty of Electrical Engineering and Information Technology

Master Thesis (Masterarbeit) ETIT-290

Master Thesis (Masterarbeit)

Rota	Duration	Semester	CP	Attendence	Self Study
WiSe & SoSe	1 Semester	4th Semester	30	-	900 h

1 **Module Structure**

No.	Course / Element	Type	CP	SWS
1	Master Thesis	P	30	-

2 **Course language**

English

3 **Teaching Content**

1. Familiarisation with the scientific problem of the task using guidelines
2. Analysis of the relevant previous scientific work
3. Development of solution approaches
4. Verification and evaluation of the solution approaches
5. Selection and realisation of the best approach
6. Scientific description of the methodology and the solution in written form

The contents and results of the Master's thesis must be processed and presented to an expert audience. The presentation must take place no later than 6 weeks after submission of the thesis.

4 **Competencies**

The student is able to work independently on a narrowly defined technical-scientific problem from his or her subject area using scientific methods. He or she is able to evaluate relevant preliminary work from the specialist literature, develop new approaches to solutions, evaluate these and finally implement a solution. Furthermore, he or she is able to present the results in writing in a structured way so that the relevant aspects of the solution are understood. The student is also able to present the results to a specialist audience and discuss them at the end.
By completing the module, students should also be able to recognize and incorporate the challenges of today's and future digital societies and thus assume social responsibility.

5 **Examinations**

Modulprüfung: The Master's thesis counts as a Module Exam.

6 **Type of Examination**

Module Exam

7 **Participation Requirements**

Recommended prerequisites: Good scientific knowledge in the respective field of the master thesis
Required prerequisites: Acquisition of 80 credit points in the Master's program.

8 **Module Type and Applicability**

Elective Module in the Master's degree program Sustainable Energy Systems.

9	**Module Supervisor** Dean of the Faculty of Electrical Engineering and Information Technology	**Faculty in charge** Faculty of Electrical Engineering and Information Technology

Version Information

Version information

V 1.0: Version of the module handbook adopted by the Department Council of the Faculty of Electrical Engineering and Information Technology on 03/05/2023.

Changes compared to the version dated 03/05/2023

- The content of the modules Design of Sustainable Products & Services, Energy Economics and Technologies, Power System Operation and Stability, Planning and Operation of Distributed Energy Sources, Principles of Sustainability, Power System Economics, Control System Operation for Electrical Power Grids and Electromagnetic Field Theory Simulation has been revised.
- The elective module Simulation and Testing Methods for Modern Power Systems has been added.
- The social commitment anchored in the study program has been added to the descriptions at module level.
- Language corrections.

Changes compared to the version dated 10/04/2024

- The elective module ETIT-220 Design and Operation of Electrical Machines was added to the catalogue Energy Systems.
- The elective module ETIT-237 Methods of Information Technology was added to the elective classes.
- Language corrections.

Changes compared to the version dated 28/03/2025

- ETIT-282 Industrial Internship: Prof. Dr. Häger as Module Supervisor, alignment of the module description with the German version in MA ETIT.
- SES-104 Module M-4: addition of Dr.-Ing. Hilbrich as Lecturer.
- Newly added:
  - ETIT-508: Smart Grid System Engineering: Safety, Security and Resilience
  - ETIT-294: Secure Communications
  - ETIT-509: Module 3-49: Components and Systems for Electric Mobility
  - ETIT-355: LAB 7: Advanced Battery and Fuel Cell Technology for Sustainable Energy Systems
- Prof. Dr.-Ing. Günlü takes over as Module Supervisor for module ETIT-238.
- Updated module descriptions for:
  - ETIT-216
  - SES-101
  - ETIT-281
- Lab 5 takes place every semester.
- ETIT-350 takes place in the summer term.
- ETIT-406 deleted.

Changes compared to the version dated 27/10/2025

- Language corrections.
- Updated module descriptions for:
  - ETIT-237: Methods of Information Technology
  - ETIT-281: Advanced Seminar
- Updated examinations:
  - ETIT-237: Methods of Information Technology
- Opened for additional study programs:
  - ETIT-294: Secure Communications opened for MA AR.
- Updated module responsibility:
  - AR-373 = ETIT-281: Prof. Palzer takes over.
- Newly added:
  - ETIT-356: Smart Grids Lab (Spina)
  - ETIT-512: Introduction to the German Language and Communication (zhb)

Changes compared to the version dated 11/03/2026

- Language corrections and formatting adjustments.
- Newly added modules:
  - ETIT-358: LAB 8 ”Digital Transmission Lab”(English version of ”Digitale Übertragungstechnik”)
  - ETIT-513: Modern Coding Systems and Applications
  - ETIT-514: GIS-Lab for Sustainable Energy Systems
- no longer offered:
  - ETIT-237: Methods of Information Technology: Statistical Signal Processing and Machine Learning
- Updated content and competencies:
  - ETIT-294: Secure Communications (content)
  - SES-102 = ETIT-505: Energy Economics and Technologies
  - ETIT-269 Align the content with the MA ETIT & AR.
- Updated examination requirements:
  - ETIT-508: Smart Grid System Engineering – Safety, Security and Resilience (partial achievements instead of module examination)
  - ETIT-407: Mobile Radio Networks 1 (oral examination 45 instead of 40 minutes; coursework explicitly stated as a prerequisite for admission to the module examination)
  - ETIT-408: Mobile Radio Networks 2 (oral examination 45 instead of 40 minutes; coursework explicitly stated as a prerequisite for admission to the module examination)
- Specification of applicability:
  - ETIT-294: Secure Communications (assignment in the study program Automation and Robotics to the profiles RRoboticsänd MMachine Learning”)
- Change of module responsibility:

- SES-102 = ETIT-505: Energy Economics and Technologies is taken over by Prof. Dr. S. Braungardt.
- SES-104 = SES-503: Planning & Operation of Distributed Energy Sources is taken over by Prof. Dr. S. Braungardt.