Kiel University
Christian-Albrechts-Universität zu Kiel

Faculty of Engineering

Module Catalogue

for Electrical and Information Engineering
Bachelor, 1-Subject
Version 2022

Table of Contents

Prologue

Information about the attendance time
In the case of the modules of the Department of Electrical and Information Engineering (module code "etit..."), the calculation of the attendance time is based on a semester with 15 weeks.

Information about the specification in the field "Form of examination"
For modules with "Other" in the field "Type of Examination" you will find the information about the type of examination in the field "Examination Name".

Information about the computer science modules
The descriptions of the computer science modules of the Bachelor's program "Electrical and Information Engineering" are currently not yet integrated in the module catalogue.

The description of the module "NF-Inf-1v - Computer Science I (2F/NF)" can be found at the following link:

mdb.ps.informatik.uni-kiel.de/show.cgi?ModData/show/ModData507

The description of the module "Inf-CompSys - Computer Systems" can be found at this link:

mdb.ps.informatik.uni-kiel.de/show.cgi?ModData/show/ModData429

Name	Code
Technical Compulsory Modules	
Organizer	
Faculty	
Faculty of Engineering	
Examination Office	

ECTS Credits	150
Evaluation	Graded

Use	Compulsory / Optional	Semester
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2022)	Compulsory	.

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Module Name	Module Code
Devices	etit1006-01a
Module Coordinator	
Prof. Dr. Hermann Kohlstedt	
Organizer	
Department of Electrical and Information Engineering - Nano Electronics	
Faculty	
Faculty of Engineering	
Examination Office	
Examination Office for Electrical Engineering and Information Technology	

ECTS Credits	7
Evaluation	Graded
Duration	One semester
Frequency	Only takes place during summer semesters
Workload per ECTS Credit	30 hours
Total Workload	210 hours
Contact Time	75 hours
Independent Study	135 hours
Teaching Language	German

Entry Requirements as Stated in the Examination Regulations

- Fundamentals of Electrical Engineering I (Module etit1001-01a)

Recommended Requirements

- Fundamentals of Electrical Engineering I and II (Modules etit1001-01a and etit1003-01a)
- Fundamentals of Circuit Technology (Module etit1004-01a)
- Mathematics for Engineering Sciences I - III (Modules mathMIng1-01a, mathMIng2-01a und math-MIng3-01a)
- Basics of Materials Science (Module mawiE013-01a)
- Computer Systems (Module Inf-CompSys)

Module Courses

Course Type	Course Name	Compul-sory/Optional	SWS
Lecture	Electronic Devices	Compulsory	3
Exercise	Electronic Devices	Compulsory	2

Examination(s)

Examination Name	Type of Examination	Evaluation	Compulsory / Optional	Weighting
Written Examination: Devices	Written Examina-tion	Graded	Compulsory	100

Course Content

Fundamentals
Silicon, doping, band model, space-charge region, drift and diffusion currents.

Electronic devices
pn diodes, LED, laser diodes, bipolar transistors, field effect transistors, power semiconductors (DIAC, TRIAC, thyristor), phototransistor.

Analog circuits
Rectifier circuits, amplifier circuits, principle of feedback, setting of operating point, small-signal parameters, basic circuits with a transistor, phase interface control, current sources, current mirrors, boost and buck converters, reference voltage sources, cascade, differential amplifier, structure of an integrated operational amplifier.

Ideal operational amplifier
Operating characteristics, circuits with inverting and non-inverting operational amplifier, non-linear applications, deviations from ideal behavior. Fundamentals of analog-to-digital converter (ADC) and digital-to-analog converter (DAC): Ideal ADC and DAC, sampling rate, oversampling, sampling theorem, aliasing, circuit example on ADC and DAC.

The module is supplemented by experiments in the practical course.

Learning Outcome

Students are able to explain the active and functional principles of the various semiconductor devices. They can also explain the basic circuits - analog and digital, discrete and integrated. The students can convey basic principles, such as negative and positive feedback for the design of electronic circuits. The students are able to present the basics for the production of a field effect transistor.

Reading List

- Harald Hartl et al., Elektronische Schaltungstechnik
- Pearson-Studium, ISBN: 978-3-8273-7321-2
- Müller, R.: Bauelemente der Halbleiterelektronik (4. Auflage), Springer 1991
- Möschwitzer, A.: Grundlagen der Halbleiter- & Mikroelektronik (Band 1 und 2), Hanser 1992
- Köstner, R., Möschwitzer, A.: Elektronische Schaltungen, Hanser 1993
- Siegl, J.: Schaltungstechnik (2. Auflage), Springer 2005
- Hoffmann, K.: Systemintegration, Oldenbourg 2003
- Jaeger, R. C.: Microelectronic Circuit Design, McGraw-Hill 1997
- Horowitz, P., Winfield, H.: The Art of Electronics (2. Auflage), Cambridge University Press 1991
- Floyd, T.: Digital Fundamentals (9. Auflage), Pearson Prentice Hall 2006
- Maxfield, C.: Bebop to the Boolean Boogie (2. Auflage), Newnes (Elsevier Science) 2003

Use	Compulsory / Optional	Semester
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2022)	Compulsory	4.
Bachelor, 1-Subject, Electrical Engineering and Business Management, (Version 2022)	Compulsory	4.

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Module Name	Module Code
Electrical Energy Technology	etit1007-01a
Module Coordinator	
Prof. Dr.-Ing. Marco Liserre	
Organizer	
Department of Electrical and Information Engineering - Power Electronics	
Faculty	
Faculty of Engineering	
Examination Office	
Examination Office for Electrical Engineering and Information Technology	

ECTS Credits	6
Evaluation	Graded
Duration	One semester
Frequency	Only takes place during summer semesters
Workload per ECTS Credit	30 hours
Total Workload	180 hours
Contact Time	60 hours
Independent Study	120 hours
Teaching Language	German

Entry Requirements as Stated in the Examination Regulations

- Fundamentals of Electrical Engineering I (Module etit1001-01a)

Recommended Requirements

- Fundamentals of Electrical Engineering I and II (Modules etit1001-01a and etit1003-01a)
- Fundamentals of Circuit Technology (Module etit1004-01a)
- Mathematics for Engineering Sciences I – III (Modules mathMIng1-01a, mathMIng2-01a and math-MIng3-01a)

Module Courses

Course Type	Course Name	Compul-sory/Optional	SWS
Lecture	Electrical Energy Technology	Compulsory	3
Exercise	Electrical Energy Technology	Compulsory	1

Examination(s)

Examination Name	Type of Examination	Evaluation	Compulsory / Optional	Weighting
Written Examination: Electrical Energy Technology	Written Examina-tion	Graded	Compulsory	100

Course Content

0 Introduction

1 Multiphase systems
1.1 Creating multiphase systems
1.2 Linking of multiphase systems
1.3 Linked three-phase systems with symmetrical generator
1.4 Symmetrical components
1.5 Faults in three-phase systems

2 Transformers
2.1 Inductors with iron core
2.2 Single-phase transformers
2.3 Three-phase transformers
2.4 Parallel operation of transformers

3 General induction machines
3.1 Induced voltage, torque, power (electromagnetic behavior)
3.2 Motor and generator operation of machines

4 Asynchronous machines
4.1 Method of operation
4.2 Electrical operating characteristics and equivalent circuit diagram
4.3 Torque behavior
4.4 Design, application and speed control

5 Synchronous machines
5.1 Method of operation
5.2 Electrical operating behavior
5.3 Torque behavior
5.4 Phase-shifting operation in the power grid

Learning Outcome

The students can explain multiphase systems and the common models of symmetrical components/space vector. They can describe the operation of transformers, induction machines including rotating field creation, asynchronous machines and synchronous machines. The students are able to determine the operating characteristics of the components of electrical energy systems. They can apply calculation procedures for three-phase networks.

Reading List

- M. Liserre: Elektrische Energietechnik Skript
- Möller, Klaus: Grundgebiete der Elektrotechnik III; Verlag der Augustinus-Buchhandlung, Aachen, 1995 (Nachdruck)
- Fischer, Rolf: Elektrische Maschinen; Hanser-Verlag, München, 2006

Use	Compulsory / Optional	Semester
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2022)	Compulsory	4.
Bachelor, 1-Subject, Electrical Engineering and Business Management, (Version 2022)	Compulsory	4.

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Module Name	Module Code
Electromagnetic Fields I	etit2001-01a
Module Coordinator	
Prof. Dr.-Ing. Ludger Klinkenbusch	
Organizer	
Department of Electrical and Information Engineeringomputational Electromagnetics	
Faculty	
Faculty of Engineering	
Examination Office	
Examination Office for Electrical Engineering and Information Technology	

ECTS Credits	6
Evaluation	Graded
Duration	One semester
Frequency	Only takes place during summer semesters
Workload per ECTS Credit	30 hours
Total Workload	180 hours
Contact Time	60 hours
Independent Study	120 hours
Teaching Language	German

Entry Requirements as Stated in the Examination Regulations

- Fundamentals of Electrical Engineering I (Module etit1001-01a)

Recommended Requirements

- Fundamentals of Electrical Engineering I and II (Modules etit1001-01a and etit1003-01a)
- Fundamentals of Circuit Technology (Module etit1004-01a)
- Mathematics for Engineering Sciences I – III (Modules mathMIng1-01a, mathMIng2-01a and math-MIng3-01a)

Module Courses

Course Type	Course Name	Compul-sory/Optional	SWS
Lecture	Electromagnetic Fields I	Compulsory	3
Exercise	Electromagnetic Fields I	Compulsory	1

Examination(s)

Examination Name	Type of Examination	Evaluation	Compulsory / Optional	Weighting
Written Examination: Electromagnetic Fields I	Written Examina-tion	Graded	Compulsory	100

Course Content

Fundamentals
Vector analysis, integral sets, Maxwell's equations, material equations, boundary conditions.

Electrostatics
Definition, field equations, potential, Coulomb integral, Poisson and Laplace equations, method of mirror images, uniqueness theorem, capacitance, potential and capacitance coefficients, dipole, point dipole, polarization, electric double layer, energy and forces in electric field.

Electric field of stationary currents
Fields in conductors, Ohm's law, boundary conditions, Kirchhoff's equations, duality conductance - capacity, dielectric absorption.

Magnetic field of stationary currents
Ampere's law, vector potential, Biot-Savart law, magnetic dipole, magnetization.

Learning Outcome

The students have a basic understanding of the field concept and can explain it. The students are familiar with procedures for mathematical and physical modeling of field problems including their problemspecific and efficient solution. They can also apply these procedures.

Reading List

- Blume S.: Theorie elektromagnetischer Felder (4. Auflage), Heidelberg: Hüthig 1994
- Lehner, G.: Elektromagnetische Feldtheorie (2. Auflage), Berlin: Springer 1994
- Dirks, H.K.: Formelsammlung zur Theoretischen Elektrotechnik, CAU Kiel, 2003.
- Wolff, I.: Grundlagen und Anwendungen der Maxwellschen Theorie (I und II), Teil I: Berlin: Springer 1996, Teil II: Mannheim: Bibliographisches Institut, 1970
- Küpfmüller, K, Kohn, G.: Theoretische Elektrotechnik und Elektronik (15. Aufl.), Berlin: Springer 1999
- Simonyi, K.: Theoretische Elektrotechnik, Berlin: Deutscher Verlag der Wissenschaften 1989
- Balanis, C.A.: Advanced Engineering Electromagnetics, New York: Wiley 1989
- Ulaby, F.T.: Fundamentals of Applied Electromagnetics: 2004, Prentice-Hall 2004

Use	Compulsory / Optional	Semester
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2022)	Compulsory	4.
Bachelor, 1-Subject, Electrical Engineering and Business Management, (Version 2022)	Compulsory	4.

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Module Name	Module Code
Electromagnetic Fields II	etit2003-01a
Module Coordinator	
Prof. Dr.-Ing. Ludger Klinkenbusch	
Organizer	
Department of Electrical and Information Engineeringomputational Electromagnetics	
Faculty	
Faculty of Engineering	
Examination Office	
Examination Office for Electrical Engineering and Information Technology	

ECTS Credits	4
Evaluation	Graded
Duration	One semester
Frequency	Only takes place during winter semesters
Workload per ECTS Credit	30 hours
Total Workload	120 hours
Contact Time	45 hours
Independent Study	75 hours
Teaching Language	German

Entry Requirements as Stated in the Examination Regulations
• Fundamentals of Electrical Engineering I (Module etit1001-01a)
Recommended Requirements
• Electromagnetic Fields I (Modul etit2001-01a)

Module Courses

Course Type	Course Name	Compul-sory/Optional	SWS
Lecture	Electromagnetic Fields II	Compulsory	2
Exercise	Electromagnetic Fields II	Compulsory	1

Examination(s)

Examination Name	Type of Examination	Evaluation	Compulsory / Optional	Weighting
Written Examination: Electromagnetic Fields II	Written Examina-tion	Graded	Compulsory	100

Course Content

Slowly varying electric and magnetic fields
Slow electrical balancing processes, law of induction, magnetic field energy, induction coefficients, forces in the magnetic field.

Rapidly varying electromagnetic fields
Plane waves, phase velocity, polarization, dispersion, group velocity, Poynting vector, waveguides (TEM, TE, TM), dielectric waveguide, electrodynamic potentials, Lorentz gauge, Hertzian and Fitzgerald dipole, reciprocity theorem.

Quasi-stationary fields
Definition, calibration, displacement current free quasi-stationary field (eddy current theory) and eddy current free quasi-stationary field.

Learning Outcome

Building up on the learning outcomes of the module "Electromagnetic Fields I", the students have understood the fundamentals of wave propagation, including the significance of the Hertzian elementary dipole, which are important for wireless and optical transmission technology, among other things. The students are able to distinguish from these rapidly varying fields the slowly varying and quasi-stationary processes in which parts of the fields can be neglected and which are necessary for modeling many technically relevant problems (especially circuits). Thus, students have understood the fundamentals required for more advanced modules (e.g., Microwave Engineering, Electromagnetic Compatibility, Optical Communications).

Reading List

- Blume S.: Theorie elektromagnetischer Felder (4. Auflage), Heidelberg: Hüthig 1994
- Lehner, G.: Elektromagnetische Feldtheorie (2. Auflage), Berlin: Springer 1994
- Dirks, H.K.: Formelsammlung zur Theoretischen Elektrotechnik, CAU Kiel, 2003.
- Wolff, I.: Grundlagen und Anwendungen der Maxwellschen Theorie (I und II), Teil I: Berlin: Springer 1996, Teil II: Mannheim: Bibliographisches Institut, 1970
- Küpfmüller, K, Kohn, G.: Theoretische Elektrotechnik und Elektronik (15. Aufl.), Berlin: Springer 1999
- Simonyi, K.: Theoretische Elektrotechnik, Berlin: Deutscher Verlag der Wissenschaften 1989
- Balanis, C.A.: Advanced Engineering Electromagnetics, New York: Wiley 1989
- Ulaby, F.T.: Fundamentals of Applied Electromagnetics: 2004, Prentice-Hall 2004
- Popovic, Z., Popovic, B.D.: Introductory Electromagnetics, Prentice-Hall 2000

Use	Compulsory / Optional	Semester
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2022)	Compulsory	5.
Bachelor, 1-Subject, Electrical Engineering and Business Management, (Version 2022)	Compulsory	5.

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Module Name	Module Code
Fundamentals of Electrical Engineering I	etit1001-01a
Module Coordinator	
Prof. Dr. Martina Gerken	
Organizer	
Department of Electrical and Information Engineering - Integrated Systems and Photonics	
Faculty	
Faculty of Engineering	
Examination Office	
Examination Office for Electrical Engineering and Information Technology	

ECTS Credits	7
Evaluation	Graded
Duration	One semester
Frequency	Only takes place during winter semesters
Workload per ECTS Credit	30 hours
Total Workload	210 hours
Contact Time	75 hours
Independent Study	135 hours
Teaching Language	German

Module Courses			
Course Type	**Course Name**	**Compul-sory/Optional**	**SWS**
Lecture	Fundamentals of Electrical Engineering I	Compulsory	3
Exercise	Fundamentals of Electrical Engineering I	Compulsory	2

Examination(s)				
Examination Name	**Type of Examination**	**Evaluation**	**Compulsory / Optional**	**Weighting**
Written Examination: Fundamentals of Electrical Engineering I	Written Examina-tion	Graded	Compulsory	100
Further Information on the Examination(s)				
Written final exam and course-related bonus deliverables in the form of online testing and participation in laboratory practice.				

Course Content

The topic of the module are steady-state processes in electrical circuits and in electric and magnetic fields. The following topics are covered:

- Basic concepts: Charge, current, potential, voltage, electric field strength.
- Two-terminals: Passive, active, linear, nonlinear, current-voltage curve, resistance, Ohm's law, ideal source, linear source, internal resistance
- Two-terminal networks: Operating point, performance tuning, node set, mesh set, equivalent resistance, equivalent voltage source, equivalent current source, superposition theorem, voltage divider, bridge circuit
- Two-ports: Current condition, two-port equations, equivalent two-port, two-port parameters, field of characteristic curves, controlled source
- Network analysis: Graph, complete tree, setting up linearly independent branch, node and mesh equations
- The electric field: Homogeneous, inhomogeneous, field lines, current density, electric potential field, electrostatic field, influence, electric flux density, permittivity, point loads, electric dipoles, capacity, equivalent capacity
- The magnetic field: Magnetic flux density, Lorentz force, Ampere's law, permeability, magnetic field strength, Biot-Savart

Learning Outcome

The students are able to name and explain the basic terms of electrical engineering. They are familiar with simple physical models for electrical engineering devices and can explain them. The students are able to calculate static and stationary electric and magnetic fields for simple geometric arrangements. In addition, they are able to transform and calculate simple electrical DC circuits with linear and nonlinear one- and two-port circuits. In the laboratory, the students are able to measure electrical variables in simple experimental setups, explain their results and operate typical electrical engineering laboratory equipment.

Reading List

Mandatory literature:

- „Elektrotechnik“ by Manfred Albach, Pearson Studium.

Further reading:

- „Grundgebiete der Elektrotechnik Band 1: Stationäre Vorgänge” by Arnold Führer, Klaus Heidemann and Wolfgang Nerreter, Hanser Fachbuchverlag.
- „Grundlagen der Elektrotechnik“ by Gert Hagmann, Aula.
- „Grundlagen der Elektrotechnik“ by Reinhold Pregla, Hüthig.

Use	Compulsory / Optional	Semester
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2022)	Compulsory	1.
Bachelor, 1-Subject, Electrical Engineering and Business Management, (Version 2022)	Compulsory	1.

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Module Name	Module Code
Fundamentals of Electrical Engineering II	etit1003-01a
Module Coordinator	
Prof. Dr. Martina Gerken	
Organizer	
Department of Electrical and Information Engineering - Integrated Systems and Photonics	
Faculty	
Faculty of Engineering	
Examination Office	
Examination Office for Electrical Engineering and Information Technology	

ECTS Credits	7
Evaluation	Graded
Duration	One semester
Frequency	Only takes place during summer semesters
Workload per ECTS Credit	30 hours
Total Workload	210 hours
Contact Time	75 hours
Independent Study	135 hours
Teaching Language	German

Recommended Requirements
• Fundamentals of Electrical Engineering I (Module etit1001-01a)

Module Courses

Course Type	Course Name	Compul-sory/Optional	SWS
Lecture	Fundamentals of Electrical Engineering II	Compulsory	3
Exercise	Fundamentals of Electrical Engineering II	Compulsory	2

Examination(s)

Examination Name	Type of Examination	Evaluation	Compulsory / Optional	Weighting
Written Examination: Fundamentals of Electrical Engineering II	Written Examina-tion	Graded	Compulsory	100

Further Information on the Examination(s)
Written final exam and course-related bonus deliverables in the form of online testing and participation in laboratory practice.

Course Content

The topic of the module are time-dependent processes in electrical and magnetic fields as well as in networks. The following topics are covered:

- Time-dependent electrical and magnetic fields
- Power and energy in electromagnetic fields
- Periodic time-dependent variables
- Linear two-terminals at sinusoidal voltage
- Networks with sinusoidal sources of the same frequency
- Networks at different frequencies
- Three-phase current
- Basics of measurement technology

Learning Outcome

The students are familiar with physical models for concentrated components and can explain them. They can explain and differentiate between the time and phasor domains. The students are able to calculate time-dependent quasi-stationary electrical and magnetic fields for simple geometric arrangements. Furthermore, they are able to calculate and dimension electrical AC circuits and filter networks. They can describe electrical measurement techniques and perform simple error analyses. Students are able to measure electrical variables in simple experimental setups in the laboratory, explain their results and operate typical electro-technical laboratory equipment.

Reading List

Mandatory literature:

- „Elektrotechnik“ by Manfred Albach, Pearson Studium.

Further reading:

- „Grundgebiete der Elektrotechnik Band 2: Zeitabhängige Vorgänge” by Arnold Führer, Klaus Heidemann and Wolfgang Nerreter, Hanser Fachbuchverlag.
- „Grundlagen der Elektrotechnik“ by Gert Hagmann, Aula.
- „Grundlagen der Elektrotechnik“ by Reinhold Pregla, Hüthig.

Use	Compulsory / Optional	Semester
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2022)	Compulsory	2.
Bachelor, 1-Subject, Electrical Engineering and Business Management, (Version 2022)	Compulsory	2.

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Module Name	Module Code
Basics of Materials Science	mawiE013-01a
Module Coordinator	
Prof. Dr. Rainer Adelung	
Organizer	
Institut für Materialwissenschaft - Funktionale Nanomaterialien	
Faculty	
Faculty of Engineering	
Examination Office	
Examination Office for Materials Science	

ECTS Credits	6
Evaluation	Graded
Duration	One semester
Frequency	Only takes place during summer semesters
Workload per ECTS Credit	30 hours
Total Workload	180 hours
Contact Time	75 hours
Independent Study	105 hours
Teaching Language	German

Recommended Requirements

- 1st half of the two-semester module Physics for students of Electrical and Information Engineering (Module MNF-phys-Ing)
- Mathematics for Engineering Sciences I (Module mathMIng1-01a)

Module Courses

Course Type	Course Name	Compul-sory/Optional	SWS
Lecture	Basics of Materials Science	Compulsory	3
Exercise	Basics of Materials Science	Compulsory	2

Examination(s)

Examination Name	Type of Examination	Evaluation	Compulsory / Optional	Weighting
Written Examination: Basics of Materials Science	Written Examina-tion	Graded	Compulsory	100

Course Content

Crystals
Potential well model, bond types, basics of quantum mechanics, matter waves, ideal crystals, fundamental lattice + atomic basis, Miller's indices, real crystals, defects, atomic diffusion.

Equilibrium thermodynamics
Temperature, equal distribution theorem, 1st law, entropy and disorder, 2nd law, free energy and minimization principle, Boltzmann distribution, Fermi distribution.

Dielectric materials
Polarizability and polarization (electron, ion, orientation polarization), special dielectrics (ferroelectricity, piezoelectricity), dielectric materials in alternating electric fields (frequency behavior, dynamic properties, dielectric losses), optical properties.

Magnetic materials
Manifestations of magnetism (dia-, para-, ferromagnetism), magnetization, magnetization curve, walls and domains, permeability, frequency response, applications.

Conductors and semiconductors
Classical treatment of free electrons in metal, Ohm's law and mobility, electron waves, Brillouin zones, band model, degree of occupation, effective density of states, intrinsic semiconductor, impurity semiconductor, location of Fermi level, law of mass action, conductivity.

Learning Outcome

Students know elementary relationships between macroscopic mechanical, optical, electrical and magnetic properties of materials and their atomic structure, including physical mechanisms relevant at the atomic level and general thermodynamic principles. In particular, they know how the quantum mechanical wave nature of conduction electrons results in their band structure and what makes the difference between direct and indirect semiconductors, furthermore they know the concept of holes in the valence band. The students have understood how the dielectric function, the magnetization and the conductivity (incl. temperature dependence) arise microscopically. The students have learned the basics of scientific thinking, how to use numerical values, formulas and principle sketches in order to make connections.

Reading List

- H. Föll: Hyperskript „Grundlagen der Materialwissenschaft für Elektro- und Informationstechniker“ https://www.tf.uni-kiel.de/matwis/amat/mw_for_et/index.html
- Fischer, H.; Hofmann, H.; Spindler, J.: Werkstoffe in der Elektrotechnik, 4. Auflage, Hanser Lehrbuch
- Schaumburg, H.: Einführung in die Werkstoffe der Elektrotechnik, B.G. Teubner, Stuttgart
- Askeland: The Science and Engineering of Materials • Shackelford: Werkstofftechnologie für Ingenieure
- G. F. Fasching: Werkstoffe für die Elektrotechnik
- W. v. Münch: Werkstoffe der Elektrotechnik

Use	Compulsory / Optional	Semester
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2022)	Compulsory	2.
Bachelor, 1-Subject, Electrical Engineering and Business Management, (Version 2022)	Compulsory	2.

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Module Name	Module Code
Fundamentals of Circuit Technology	etit1004-01a
Module Coordinator	
Prof. Dr. Robert Rieger	
Organizer	
Department of Electrical and Information Engineering - Networked Electronic Systems	
Faculty	
Faculty of Engineering	
Examination Office	
Examination Office for Electrical Engineering and Information Technology	

ECTS Credits	7
Evaluation	Graded
Duration	One semester
Frequency	Only takes place during winter semesters
Workload per ECTS Credit	30 hours
Total Workload	210 hours
Contact Time	75 hours
Independent Study	135 hours
Teaching Language	German

Recommended Requirements

- Fundamentals of Electrical Engineering I and II (Modules etit1001-01a and etit1003-01a)
- Mathematics for Engineering Sciences I and II (Modules mathMIng1-01a and mathMIng2-01a)

Module Courses

Course Type	Course Name	Compul-sory/Optional	SWS
Lecture	Fundamentals of Circuit Technology	Compulsory	3
Exercise	Fundamentals of Circuit Technology	Compulsory	2

Examination(s)

Examination Name	Type of Examination	Evaluation	Compulsory / Optional	Weighting
Written Examination: Fundamentals of Circuit Technology	Written Examination	Graded	Compulsory	100

Course Content
The topic of the module is the analysis of time-dependent processes in electrical networks. The following topics are covered: • Source transformation and source shifting (Norton and Thevenin equivalent circuits) • Calculation of transient processes via differential equations (RC-circuits, RL-circuits) • Calculation of transient processes via differential equations (RLC circuits) • Harmonic analysis and synthesis of periodic waveforms using the Fourier series • Analysis of non-periodic signals using the Fourier integral • Network analysis using the Laplace transformation • Methods of mesh current and node potential analysis for network calculation • Introduction of basic circuits (operational amplifier with feedback, current mirror, ring oscillator). • Technical tools for network analysis (numerical simulation, symbolic calculation).
Learning Outcome
The students are familiar with the basic network analysis methods and are able to select the method suitable for solving the problem. They are proficient in calculating time-dependent processes in linear networks (sinusoidal and non-sinusoidal, periodic and aperiodic) and can determine the time characteristics of currents and voltages as a result of electrical stimulation. The students are familiar with procedures for network simplification (source transformation and source shifting, matrix procedures) and can apply them. They are able to analyze the basic behavior of simple circuits. They also have knowledge of the most important tools for result verification and can name them.
Reading List
• Albach, M.: Grundlagen der Elektrotechnik 2 („Periodische und nicht- periodische Signalformen“) – 1. Auflage, Pearson Verlag, ISBN 978-3-8273-71-08-9 • Schmidt, LP.; Schaller, G.; Martius, S.: Grundlagen der Elektrotechnik 3 („Netzwerke”), Pearson Verlag

Use	**Compulsory / Optional**	**Semester**
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2022)	Compulsory	3.
Bachelor, 1-Subject, Electrical Engineering and Business Management, (Version 2022)	Compulsory	3.

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Module Name	Module Code
Microwave Engineering I	etit1010-01a
Module Coordinator	
Prof. Dr.-Ing. Michael Höft	
Organizer	
Department of Electrical and Information Engineering - Microwave Engineering	
Faculty	
Faculty of Engineering	
Examination Office	
Examination Office for Electrical Engineering and Information Technology	

ECTS Credits	4
Evaluation	Graded
Duration	One semester
Frequency	Only takes place during winter semesters
Workload per ECTS Credit	30 hours
Total Workload	120 hours
Contact Time	45 hours
Independent Study	75 hours
Teaching Language	German

Entry Requirements as Stated in the Examination Regulations
• Fundamentals of Electrical Engineering I (Module etit1001-01a)
Recommended Requirements
• Electromagnetic Fields I (Module etit2001-01a)

Module Courses

Course Type	Course Name	Compul-sory/Optional	SWS
Lecture	Microwave Engineering I	Compulsory	2
Exercise	Microwave Engineering I	Compulsory	1

Examination(s)

Examination Name	Type of Examination	Evaluation	Compulsory / Optional	Weighting
Written Examination: Microwave Engineering I	Written Examination	Graded	Compulsory	100

Course Content

Introduction to high frequency technology
Frequency spectrum, transmission line.

Fundamentals of nonlinear circuits
Classification of nonlinear circuits, calculation with Taylor series, nonlinear distortion, distortion factor, intermodulation, blockade, calculation with multiple Fourier series, description function, parametric calculation, mixing.

Fundamentals of line theory
Transmission lines, line equivalent circuit, telegraph equations, wave equation, lines in steady state, propagation constant, characteristic impedance, reflection factor, standing wave ratio, wave sizes, current and voltage distribution, impedance transformation, line resonators and filter designs based on these, circuit analysis, transmission matrix, scattering matrix, basic knowledge of Smith chart.

The acquired competences are relevant for all areas of electrical engineering where propagation phenomena play a role. This applies, for example, to power supply networks as well as to fast digital circuits.

Learning Outcome

The students know and understand the basics of high-frequency technology and can apply them to analyze and evaluate corresponding circuits.
The students are familiar with various nonlinear electronic circuits and can classify in which circuits the nonlinearity is undesirable and e.g. causes distortions or is deliberately used or even necessary to generate circuit functions. The students are able to apply mathematical methods to calculate nonlinear circuits and determine which approximate solution is reasonable for which cases and evaluate the solution of the calculation.
Furthermore, the students are familiar with electrical circuits and systems with distributed switching elements in which propagation times occur. The students can describe and calculate corresponding circuits on the basis of transmission line theory using one-dimensional wave propagation on transmission lines in a sinusoidal steady state and with pulse-shaped excitation in order to apply the elements as propagation media and switching elements. Students are able to investigate and evaluate the solution.

Reading List

- Höft, M.: Leitungstheorie, Vorlesungsumdruck, CAU Kiel, 2015.
- Unger, H.-G.: Elektromagnetische Wellen auf Leitungen, Hüthig, 1996.
- Unger, H.-G., Schultz, W.: Elektronische Bauelemente und Netzwerke I+II, Vieweg.
- Chua, L. O., Desoer, A. C., Kuh, E. S.: Linear and Nonlinear Circuits, McGraw-Hill, 1987.

Use	Compulsory / Optional	Semester
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2022)	Compulsory	5.
Bachelor, 1-Subject, Electrical Engineering and Business Management, (Version 2022)	Compulsory	5.

↑

Module Name	Module Code
Microwave Engineering II	etit2005-01a
Module Coordinator	
Prof. Dr.-Ing. Michael Höft	
Organizer	
Department of Electrical and Information Engineering - Microwave Engineering	
Faculty	
Faculty of Engineering	
Examination Office	
Examination Office for Electrical Engineering and Information Technology	

ECTS Credits	6
Evaluation	Graded
Duration	One semester
Frequency	Only takes place during summer semesters
Workload per ECTS Credit	30 hours
Total Workload	180 hours
Contact Time	75 hours
Independent Study	105 hours
Teaching Language	German

Entry Requirements as Stated in the Examination Regulations

- Fundamentals of Electrical Engineering I (Module etit1001-01a)

Recommended Requirements

- Electromagnetic Fields I and II (Modules etit2001-01a and etit2003-01a)
- Microwave Engineering I (Module etit1010-01a)

Module Courses

Course Type	Course Name	Compul-sory/Optional	SWS
Lecture	Microwave Engineering II	Compulsory	3
Exercise	Microwave Engineering II	Compulsory	2

Examination(s)

Examination Name	Type of Examination	Evaluation	Compulsory / Optional	Weighting
Written Examination: Microwave Engineering II	Written Examination	Graded	Compulsory	100

Course Content

In-depth study of transmission line theory (building on the fundamentals of transmission line theory taught in the " Microwave Engineering 1" module)
Matching circuits with Smith chart, traveling waves, coupled lines.

Fundamentals of antennas
Radiation, far-field approximation, characteristics of antennas, technical antenna shapes.

Wave propagation
Ground waves, space waves, multipath propagation, fading.

High frequency transmitters and power generation
Basic operating modes of power amplifiers (A, B, AB and C operation), transmitter amplifiers with tubes (klystron, traveling wave tube, magnetron) and semiconductors (transistors, diodes).

High frequency reception
Preamplifier with MESFET, overlay reception, sensitivity and noise.

Learning Outcome

The students know and understand high-frequency components and subsystems as well as related wave propagation effects. They can explain their interaction in order to be able to describe, in particular, an analog transmission link consisting of transmitter, transmission channel and receiver. The students are familiar with wired transmission links, but in particular with wireless transmission links consisting of transmitting/receiving antennas with an intermediate radio link, such as can be found in mobile and satellite links. The students are able to calculate, analyze and evaluate the transmission characteristics of the individual elements.

Reading List

- Höft, M.: Leitungstheorie, Vorlesungsumdruck, CAU Kiel, 2015.
- Höft, M.: Hochfrequenztechnik - Antennen, Sender, Empfänger, Vorlesungsumdruck, CAU Kiel, 2015.
- Unger, H.-G.: Elektromagnetische Wellen auf Leitungen, Hüthig, 1996.
- Zinke, O., Brunswig, H.: Hochfrequenztechnik 1, Springer 1995.
- Pozar, D. M.: Microwave Engineering, Wiley, 2005.
- Unger, H.-G.: Hochfrequenztechnik in Funk und Radar, Teubner 1994.
- Voges, E.: Hochfrequenztechnik, Band 1 und 2, Hüthig-Verlag, 1986.
- Unger, H.-G., Schultz, W.: Elektronische Bauelemente und Netzwerke I+II, Vieweg.

Use	Compulsory / Optional	Semester
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2022)	Compulsory	6.
Bachelor, 1-Subject, Electrical Engineering and Business Management, (Version 2022)	Compulsory	6.

↑

Module Name	Module Code
Mathematics for Engineering Sciences I	mathMIng1-01a
Module Coordinator	
Prof. Dr. Walter Bergweiler	
Organizer	
Sektion Mathematik	
Faculty	
Faculty of Mathematics and Natural Sciences	
Examination Office	
Prüfungsamt Mathematik	

ECTS Credits	8
Evaluation	Graded
Duration	ein Semester
Frequency	Only takes place during winter semesters
Workload per ECTS Credit	30 Stunden
Total Workload	240 Stunden
Contact Time	84 Stunden
Independent Study	156 Stunden

Module Courses			
Course Type	**Course Name**	**Compul-sory/Optional**	**SWS**
Lecture	Mathematik für die Ingenieurwissenschaften I	Compulsory	4
Exercise	Mathematik für die Ingenieurwissenschaften I	Compulsory	2
Prerequisits for Admission to the Examination(s)			
Regelmäßige Teilnahme an der Übung und Prüfungsvorleistungen können gefordert werden gemäß §4a der Fachprüfungsordnung der Mathematik von 2017 bzw. §5 der Fachprüfungsordnung der Mathematik von 2020/23. Einzelheiten werden zu Beginn der Veranstaltung bekannt gegeben. Teilnahme an der Vorlesung wird dringend empfohlen. Teilnahme an der Probeklausur wird gefordert.			

Examination(s)				
Examination Name	**Type of Examination**	**Evaluation**	**Compulsory / Optional**	**Weighting**
Written or Oral Examination: Mathematics for Engineering Sciences I	Written or Oral Examination	Graded	Compulsory	-
Further Information on the Examination(s)				
Klausur (max. 180 Minuten) oder mündliche Prüfung (max. 30 Min.), benotet, Gewichtung 100%				

Course Content

Grundlagen:
- Mengen, Funktionen, reelle und komplexe Zahlen
- Beweistechniken, insb. vollständige Induktion

Beweistechniken, insb. vollständige Induktion Lineare Algebra (ca. 1,5 SWS):
- Euklidische Räume: Vektoren, Skalarprodukt, Matrizen linearer Abbildungen, Vektorprodukt im R^3
- analytische Geometrie im R^2, R^3
- Vektorräume (mit Fokus auf Teilräume des Rn), lineare Unabhängigkeit, Basis, Dimension
- Lineare Abbildungen, Matrizen, Rang, lineare Gleichungssysteme
- Determinanten, inverse Matrix, Cramersche Regel, Laplacescher Entwicklungssatz

Analysis (ca. 2,5 SWS):
- Folgen reeller Zahlen, Konvergenz, Cauchyfolgen
- Stetigkeit, Sätze über stetige Funktionen, Polynome, Nullstellen, rationale Funktionen
- Differentialrechnung: Eigenschaften differenzierbarer Funktionen und Differentiationsregeln, Differentiation elementarer Funktionen, Mittelwertsatz, Taylorsche Formel, Extrema, Regel von l'Hospital
- Unendliche Reihen (reell): Konvergenzkriterien, Potenzreihen, Taylorreihen
- Exponentialfunktion und Logarithmus (reell),
- trigonometrische Funktionen (Motivation am Einheitskreis), Hyperbelfunktionen

Learning Outcome

Die Studierenden haben erste Grundlagen der Ingenieurmathematik erworben, insbesondere in der Linearen Algebra sowie der eindimensionalen Analysis, und beherrschen die Grundlagen der mathematischen Methodik. Sie sind zum Selbststudium befähigt.

Reading List

- K. Meyberg, P. Vachenauer; "Höhere Mathematik 1", Springer
- weitere Literatur wird ggf. in den Lehrveranstaltungen bekannt gegeben

Additional Information

Bei der Berechnung der Präsenzzeit wurde ein Semester mit 14 Wochen zugrunde gelegt.

Use	Compulsory / Optional	Semester
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2022)	Compulsory	1.
Bachelor, 1-Subject, Electrical Engineering and Business Management, (Version 2022)	Compulsory	1.

↑

Module Name	Module Code
Mathematics for Engineering Sciences II	mathMIng2-01a
Module Coordinator	
Prof. Dr. Walter Bergweiler	
Organizer	
Sektion Mathematik	
Faculty	
Faculty of Mathematics and Natural Sciences	
Examination Office	
Prüfungsamt Mathematik	

ECTS Credits	8
Evaluation	Graded
Duration	ein Semester
Frequency	Only takes place during summer semesters
Workload per ECTS Credit	30 Stunden
Total Workload	240 Stunden
Contact Time	84 Stunden
Independent Study	156 Stunden

Recommended Requirements
Kenntnis der Lerninhalte des Moduls Mathematik für die Ingenieurwissenschaften I (Modul mathMIng1-01a)

Module Courses

Course Type	Course Name	Compul-sory/Optional	SWS
Lecture	Mathematik für die Ingenieurwissenschaften II	Compulsory	4
Exercise	Mathematik für die Ingenieurwissenschaften II	Compulsory	2

Prerequisits for Admission to the Examination(s)

Regelmäßige Teilnahme an der Übung und Prüfungsvorleistungen können gefordert werden gemäß §4a der Fachprüfungsordnung der Mathematik von 2017 bzw. §5 der Fachprüfungsordnung der Mathematik von 2020/23. Einzelheiten werden zu Beginn der Veranstaltung bekannt gegeben. Teilnahme an der Vorlesung wird dringend empfohlen. Teilnahme an einer Probeklausur wird gefordert.

Examination(s)

Examination Name	Type of Examination	Evaluation	Compulsory / Optional	Weighting
Written or Oral Examination: Mathematics for Engineering Sciences II	Written or Oral Examination	Graded	Compulsory	-

Further Information on the Examination(s)

Klausur (max. 180 Minuten) oder mündliche Prüfung (max. 30 Minuten), benotet, Gewichtung 100%

Course Content
Analysis (ca. 0,5 SWS): • Integralrechnung: Stammfunktion, unbestimmtes Integral, Substitutionsregel, partielle Integration, Partialbruchzerlegung, Riemann-Integral, Beispiele: stetige und monotone Funktionen, Hauptsatz der Differential- und Integralrechnung, (Übungen: Vertiefungen zur Partialbruchzerlegung) • Uneigentliche Integrale (Übungen: Gammafunktion) Lineare Algebra (ca. 0,5 SWS): • Eigenwerte und Eigenvektoren, charakteristisches Polynom • Skalarprodukt und Norm, Euklidische Vektorräume, orthogonale Abbildungen, Orthonormalisierung, Cauchy-Schwarz-Ungleichung, Wiederholung und Vertiefung (ca. 0,5 SWS): • Folgen und Reihen komplexer Zahlen • Funktionen mit komplexen Argumenten (insb. Exponentialfunktionen) Analysis, Vertiefungen (ca. 2,5 SWS): • Fourierreihen: Konvergenzfragen, gleichmäßige Konvergenz, gliedweise Differentiation und Integration, Besselsche Ungleichung, trigonometrische Funktionen als Orthonormalsystem • Topologische Begriffe im Rn : offen, abgeschlossen, beschränkt, kompakt, Konvergenz • Funktionen im Rn : Stetigkeit, Differenzierbarkeit, Tangentialebene, Richtungsableitung, partielle Ableitung, Gradient, Richtung des stärksten Anstiegs • Taylorsche Formel, Extrema von Funktionen in mehreren Variablen (Übungen: Multiplikatorenregel von Lagrange)
Learning Outcome
Die Studierenden haben weitere Grundlagen der Ingenieurmathematik erworben, insbesondere in der eindimensionalen Integralrechung und höherdimensionalen Differentialrechnung sowie der Linearen Algebra.
Reading List
• K. Meyberg, P. Vachenauer. „Höhere Mathematik 1-2“. Springer. • Weitere Literatur wird ggf. in den Lehrveranstaltungen bekanntgegeben.
Additional Information
Bei der Berechnung der Präsenzzeit wurde ein Semester mit 14 Wochen zugrundegelegt.

Use	**Compulsory / Optional**	**Semester**
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2022)	Compulsory	1.
Bachelor, 1-Subject, Electrical Engineering and Business Management, (Version 2022)	Compulsory	1.

↑

Module Name	Module Code
Mathematics for Engineering Sciences III	mathMIng3-01a
Module Coordinator	
Prof. Dr. Walter Bergweiler	
Organizer	
Sektion Mathematik	
Faculty	
Faculty of Mathematics and Natural Sciences	
Examination Office	
Prüfungsamt Mathematik	

ECTS Credits	8
Evaluation	Graded
Duration	ein Semester
Frequency	Only takes place during winter semesters
Workload per ECTS Credit	30 Stunden
Total Workload	240 Stunden
Contact Time	84 Stunden
Independent Study	156 Stunden

Recommended Requirements
Kenntnis der Lerninhalte der Module Mathematik für die Ingenieurwissenschaften I (Modul mathMIng1-01a), Mathematik für die Ingenieurwissenschaften II (Modul mathMIng2-01a)

Module Courses

Course Type	Course Name	Compul-sory/Optional	SWS
Lecture	Mathematik für die Ingenieurwissenschaften III	Compulsory	4
Exercise	Mathematik für die Ingenieurwissenschaften III	Compulsory	2

Prerequisits for Admission to the Examination(s)
Regelmäßige Teilnahme an der Übung und Prüfungsvorleistungen können gefordert werden gemäß §4a der Fachprüfungsordnung der Mathematik von 2017 bzw. §5 der Fachprüfungsordnung der Mathematik von 2020/23. Einzelheiten werden zu Beginn der Veranstaltung bekannt gegeben. Teilnahme an der Vorlesung wird dringend empfohlen. Teilnahme an einer Probeklausur wird gefordert.

Examination(s)				
Examination Name	**Type of Examination**	**Evaluation**	**Compulsory / Optional**	**Weighting**
Written or Oral Examination: Mathematics for Engineering Sciences III	Written or Oral Examination	Graded	Compulsory	-
Further Information on the Examination(s)				
Klausur (max. 180 Minuten) oder mündliche Prüfung (max. 30 Minuten), benotet, Gewichtung 100%				

Course Content

- Integralrechnung im Rn : Gebietsintegral, iterierte Integrale (Fubini), Volumen, Substitutionsregel: Polar- und Kugelkoordinaten
- Vektorfelder, Bogenlängen, Kurvenintegrale
- Oberflächenintegrale: Divergenz, Rotation, Rechnen mit „nabla“, Wegunabhängigkeit, Potentiale, Integralsätze von Gauß und Stokes
- Gewöhnliche Differentialgleichungen 1. Ordnung: Richtungselemente, Lösungsmenge, homogen/inhomogen, implizit/explizit, Variation der Konstanten, spezielle Differentialgleichungen 1. und 2. Ordnung, Potenzreihenansatz
- Existenzsatz von Picard-Lindelöf und Peano, stetige Abhängigkeit von Anfangsbedingungen
- Lineare Differentialgleichungen höherer Ordnung und lineare Systeme: Fundamentalsystem, Wronski-Determinante, Variation der Konstanten, charakteristisches Polynom bei konstanten Koeffizienten, Bestimmung reeller Fundamentalsysteme

Learning Outcome

Die Studierenden haben die Kenntnisse der Ingenieurmathematik weiter vertieft. Insbesondere haben sie die Grundlagen der höherdimensionalen Integralrechung und der höherdimensionalen Integralsätze sowie der Theorie gewöhnlicher Differentialgleichungen erworben.

Reading List

- K. Meyberg, P. Vachenauer. „Höhere Mathematik 1-2“. Springer.
- Weitere Literatur wird ggf. in den Lehrveranstaltungen bekanntgegeben.

Additional Information

Bei der Berechnung der Präsenzzeit wurde ein Semester mit 14 Wochen zugrundegelegt.

Use	Compulsory / Optional	Semester
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2022)	Compulsory	1.
Bachelor, 1-Subject, Electrical Engineering and Business Management, (Version 2022)	Compulsory	1.

↑

Module Name	Module Code
Communications	etit1009-01a
Module Coordinator	
Prof. Dr.-Ing. Stephan Pachnicke	
Organizer	
Department of Electrical and Information Engineering - Communications	
Faculty	
Faculty of Engineering	
Examination Office	
Examination Office for Electrical Engineering and Information Technology	

ECTS Credits	7
Evaluation	Graded
Duration	One semester
Frequency	Only takes place during winter semesters
Workload per ECTS Credit	30 hours
Total Workload	210 hours
Contact Time	75 hours
Independent Study	135 hours
Teaching Language	German

Entry Requirements as Stated in the Examination Regulations

- Fundamentals of Electrical Engineering I (Module etit1001-01a)

Recommended Requirements

- Signals and Systems I and II (Modules etit1005-01a and etit1008-01a)

Module Courses

Course Type	Course Name	Compul-sory/Optional	SWS
Lecture	Communications	Compulsory	3
Exercise	Communications	Compulsory	2

Examination(s)

Examination Name	Type of Examination	Evaluation	Compulsory / Optional	Weighting
Written Examination: Communications	Written Examina-tion	Graded	Compulsory	100

Course Content

Fundamental terms
Message, information, redundancy, code, signals and models in telecommunications.

Elements of telecommunications systems
Typical transmitter and receiver structures for analog and digital transmission, basics of multiple access methods TDMA, FDMA, CDMA, analog and digital source signals, discretization of analog sources.

Transmission channels:
Equivalent baseband representation, complex envelope, Hilbert transform and analytical signal, quadrature mixing, equivalent baseband systems, baseband channel, equivalent baseband representation of bandpass noise, idealized channel models, AWGN channel, linear and nonlinear distortions, real transmission channels: satellite transmission channel, optical transmission channel, wireless channel.

Modulation techniques in telecommunications
Linear modulation, single sideband AM, vestigial sideband AM, quadrature modulation, synchronous and envelope demodulation, disturbance behavior, nonlinear modulation, influence of linear channel distortion in AM and FM. Digital Signal Transmission: ISI and first Nyquist condition, eye diagram, bandwidth and spectrum of a data signal, noise-adaptive filter (matched filter), bit error probability, line coding, partial response coding, partial response precoding, bandpass transmission, linear and nonlinear modulation formats, bandpass transmission with linear modulation, signal space constellations for QAM and PSK, offset QPSK (O-QPSK), differential PSK modulation (DPSK, DQPSK), demodulation of linear formats, bandpass transmission with nonlinear modulation, discrete frequency modulation (FSK), minimum shift keying (MSK), Gaussian minimum shift keying (GMSK), continuous phase modulation (CPM), spectral characteristics, receiver structures.

Clock and carrier synchronization
Clock synchronization, correlative clock recovery, bit error probability with sampling jitter, carrier synchronization, Costas and squaring loop.

Learning Outcome

The students can name and explain the fundamental terms of telecommunications. They know models for different transmission channels and the most important modulation methods and can explain them. The students can describe typical transmitter and receiver structures in telecommunications, and they can explain how clock and carrier synchronization methods work. Students are able to calculate the bit error probability for different modulation formats.

Reading List

- Kammeyer, K. D., Dekorsy, A.: Nachrichtenübertragung; 6. Auflage; Springer Vieweg, Wiesbaden, 2018.
- Barry, J. R., Lee, E. A., Messerschmitt, D. G.: Digital Communication; 3rd Edition, Springer, New York, 2004.
- Höher P.A.: Grundlagen der digitalen Informationsübertragung: Von der Theorie zu Mobilfunkanwendungen; 2. Auflage, Springer Vieweg, Wiesbaden, 2013.

Use	Compulsory / Optional	Semester
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2022)	Compulsory	5.
Bachelor, 1-Subject, Electrical Engineering and Business Management, (Version 2022)	Compulsory	5.

↑

Module Name	Module Code
Numerical Mathematics in Engineering	mathNMfdI-01a
Module Coordinator	
Prof. Dr. Steffen Börm	
Organizer	
Sektion Mathematik	
Faculty	
Faculty of Mathematics and Natural Sciences	
Examination Office	
Prüfungsamt Mathematik	

ECTS Credits	5
Evaluation	Graded
Duration	ein Semester
Frequency	Only takes place during summer semesters
Workload per ECTS Credit	30 Stunden
Total Workload	150 Stunden
Contact Time	56 Stunden
Independent Study	94 Stunden

Recommended Requirements
Kenntnis der Lerninhalte der Module Mathematik für die Ingenieurwissenschaften I (Modul mathMIng1-01a), Mathematik für die Ingenieurwissenschaften II (Modul mathMIng2-01a), Mathematik für die Ingenieurwissenschaften III (Modul mathMIng3-01a).

Module Courses

Course Type	Course Name	Compulsory/Optional	SWS
Lecture	Numerische Mathematik für die Ingenieurwissenschaften	Compulsory	2
Exercise	Numerische Mathematik für die Ingenieurwissenschaften	Compulsory	2

Prerequisits for Admission to the Examination(s)
Prüfungsvorleistungen können gefordert werden gemäß §4a der Fachprüfungsordnung der Mathematik von 2017 bzw. §5 der Fachprüfungsordnung der Mathematik von 2020/23. Einzelheiten werden zu Beginn der Veranstaltung bekannt gegeben. Teilnahme an der Vorlesung und der Übung wird dringend empfohlen.

Examination(s)				
Examination Name	**Type of Examination**	**Evaluation**	**Compulsory / Optional**	**Weighting**
Written or Oral Examination: Numerical Mathematics in Engineering	Written or Oral Examination	Graded	Compulsory	100
Further Information on the Examination(s)				
Klausur (max. 180 Minuten) oder mündliche Prüfung (max. 30 Minuten), benotet, Gewichtung 100%				

Course Content

Das Modul bietet eine Einführung in grundlegende numerische Verfahren, die bei der Behandlung ingenieurwis-
senschaftlicher Fragestellungen zum Einsatz kommen, darunter

- direkte Lösungsverfahren für lineare Gleichungssysteme mittels LR- und QR-Zerlegung,
- iterative Lösungsverfahren für nichtlineare Gleichungssysteme wie die Newton-Iteration,
- iterative Lösungsverfahren für Eigenwertprobleme,
- polynomielle Approximation von Funktionen, beispielsweise per Interpolation,
- Quadraturformeln für die numerische Integration sowie
- Zeitschrittverfahren für die Approximation der Lösungen gewöhnlicher Differentialgleichungen.

Neben algorithmischen Aspekten werden auch die mathematische Analyse und die Implementierung der behandelten Techniken diskutiert.

Learning Outcome

Die Studierenden sind in der Lage, geeignete numerische Verfahren für eine Aufgabenstellung auszuwählen, zu implementieren und mathematisch zu analysieren.

Reading List

- Eigenes Skript
- Dahmen, Reusken. „Numerik für Ingenieure und Naturwissenschaftler“.

Additional Information

Bei der Berechnung der Präsenzzeit wurde ein Semester mit 14 Wochen zugrundegelegt.

Use	Compulsory / Optional	Semester
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2022)	Compulsory	.
Bachelor, 1-Subject, Electrical Engineering and Business Management, (Version 2022)	Compulsory	.

↑

Module Name	Module Code
Physics for Electrical Engineering and Information Technology	MNF-phys-Ing
Module Coordinator	
Organizer	
Sektion Physik	
Faculty	
Faculty of Mathematics and Natural Sciences	
Examination Office	
Prüfungsamt Physik	

ECTS Credits	8
Evaluation	Graded
Frequency	
Teaching Language	German

Examination(s)				
Examination Name	**Type of Examination**	**Evaluation**	**Compulsory / Optional**	**Weighting**
Written or Oral Examination: Physics for Electrical Engineering and Information Technology	Written or Oral Examination	Graded	Compulsory	100

Course Content
Learning Outcome
Reading List

Use	Compulsory / Optional	Semester
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2022)	Compulsory	1.
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2017)	Compulsory	1.
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2016)	Compulsory	1.
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2015)	Compulsory	1.
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2014)	Compulsory	1.
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2010)	Compulsory	1.
Bachelor, 1-Subject, Electrical Engineering and Business Management, (Version 2022)	Compulsory	1.
Bachelor, 1-Subject, Electrical Engineering and Business Management, (Version 2017)	Compulsory	1.
Bachelor, 1-Subject, Electrical Engineering and Business Management, (Version 2016)	Compulsory	1.
Bachelor, 1-Subject, Electrical Engineering and Business Management, (Version 2015)	Compulsory	1.
Bachelor, 1-Subject, Electrical Engineering and Business Management, (Version 2014)	Compulsory	1.
Bachelor, 1-Subject, Electrical Engineering and Business Management, (Version 2010)	Compulsory	1.

↑

Module Name	Module Code
Principles of Power Electronics	etit2004-01a
Module Coordinator	
Prof. Dr.-Ing. Marco Liserre	
Organizer	
Department of Electrical and Information Engineering - Power Electronics	
Faculty	
Faculty of Engineering	
Examination Office	
Examination Office for Electrical Engineering and Information Technology	

ECTS Credits	4
Evaluation	Graded
Duration	One semester
Frequency	Only takes place during winter semesters
Workload per ECTS Credit	30 hours
Total Workload	120 hours
Contact Time	45 hours
Independent Study	75 hours
Teaching Language	English

Entry Requirements as Stated in the Examination Regulations

- Fundamentals of Electrical Engineering I (Module etit1001-01a)

Module Courses

Course Type	Course Name	Compul-sory/Optional	SWS
Lecture	Principles of Power Electronics	Compulsory	2
Exercise	Principles of Power Electronics	Compulsory	1

Examination(s)

Examination Name	Type of Examination	Evaluation	Compulsory / Optional	Weighting
Written Examination: Principles of Power Electronics	Written Examina-tion	Graded	Compulsory	100

Course Content

1. Introduction: Power electronics as part of power and automation engineering

2. Power semiconductors
   - pn-Junction and signal diodes
   - Power diodes
   - Power bipolar transistors
   - Power MOSFET
   - Power IGBT
   - Thyristors
   - Wide-band-gap power devices
   - Packaging of power semiconductors

3. Self-commutated power converters: DC/DC converters
   - Quasi-stationary operation
   - Buck converter
   - Boost converter
   - Buck-boost converter
   - Choice of the output capacity
   - Extension to multi-quadrant operation
   - Control methods

4. Self-commutated power converters: Inverters
   - Single-phase voltage source inverter
   - Square-wave operation
   - Basic principles of the Pulse Width Modulation (PWM)
   - Bipolar and unipolar modulations
   - Sinusoidal modulation
   - Control characteristic and overmodulation
   - Deadtime
   - Three-phase voltage source inverters
   - Overmodulation (up to six-steps operation)
   - Spacevector modulation
   - Applications of inverters in electric drives and smart grid

5. Line-commutated power converters and power quality issues
   - One-pulse power converter
   - Single phase full-bridge converter
   - Commutation between thyristors
   - Star-connected three-phase converter
   - Three-phase full bridge converter
   - 12-pulses power converters for High Voltage DC (HVDC) applications
   - Not-sinusoidal voltages and currents, distorted power
   - Propagation of harmonics and power quality factors

Learning Outcome

Power electronics are used in the majority of electrical energy applications, such as the power generation. Due to its interdisciplinary character, it is an example of system-oriented work. The module imparts knowledge and skills on the basic processes, circuits and components such as self-commutated power converters, line-commutated power converters, grid perturbations and power semiconductors. These topics have to be seen from the students in the optic that today more than 60% of the electrical energy is converted electronically before consumption. The students should acquire a basic understanding of power electronics, know the essential state of the art and be able to independently assess the operation of known and unknown circuits. The use of power semiconductor to control the voltage amplitude and frequency waveforms in power converters is an essential new learning content. In addition, the function of power semiconductors is taught.

Reading List
• M. Liserre: Principle of Power Electronics Script • Mohan, N.; Undeland, T.M., Robbins, W.P.: Power Electronics – Converters, Application and Design, John Wiley, New York, 3. Auflage, 2003 • Michel, M.: Leistungselektrtonik – Eine Einführung, Springer-Verlag, Berlin, Heidelberg, New York, 1996

Use	**Compulsory / Optional**	**Semester**
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2022)	Compulsory	5.
Bachelor, 1-Subject, Electrical Engineering and Business Management, (Version 2022)	Compulsory	5.

↑

Module Name	Module Code
Introductory Seminar Electrical Engineering	etit1002-01a
Module Coordinator	
Dipl.-Ing. Dr.-Ing. Michael Meißer	
Organizer	
Department of Electrical and Information Engineering	
Faculty	
Faculty of Engineering	
Examination Office	
Examination Office for Electrical Engineering and Information Technology	

ECTS Credits	2
Evaluation	Not graded
Duration	Two semesters
Frequency	Takes place every semester
Workload per ECTS Credit	30 hours
Total Workload	60 hours
Contact Time	45 hours
Independent Study	15 hours
Teaching Language	German

Module Courses			
Course Type	**Course Name**	**Compul-sory/Optional**	**SWS**
Seminar	Introductory Seminar Electrical Engineering (Part 1)	Compulsory	1,5
Seminar	Introductory Seminar Electrical Engineering (Part 2)	Compulsory	1,5

Examination(s)				
Examination Name	**Type of Examination**	**Evaluation**	**Compulsory / Optional**	**Weighting**
Assignment: Introductory Seminar Electrical Engineering	Assignment	Not graded	Compulsory	100

Course Content
The introductory seminar makes it possible to get to know the various chairs of electrical engineering and information technology at the Faculty of Engineering. The respective working focuses and research topics will be presented and current challenges will be discussed. Some of the people working at the chairs will be introduced by way of example. Furthermore, the seminar imparts knowledge and supports the acquisition of competences, which bring the knowledge gained in the technical subjects into application, into networking and into transfer. Central points are: • Building and practicing writing skills and the ability to provide constructive feedback on scientific writing, • Learning the basics of data analysis and how to present data in the form of descriptive graphs, • Learning the basics of reading and drafting schematics, • Developing one's own connection to the discipline and one's own professional development. All aspects incorporate the use of appropriate software tools.
Learning Outcome
The students are familiar with the chairs of the Faculty of Engineering and have become acquainted with the respective contact persons. The students express themselves elaborately in written form on topics of their subject. Students are able to present data graphically in a clear and informative manner. The students are able to understand circuit diagrams in principle and to analyze them in first steps. They can draw simple circuit diagrams in accordance with standards. The students reflect on the job profiles of their subject and their ideas about their professional future.
Reading List
Appropriate literature is made available via OLAT.

Use	Compulsory / Optional	Semester
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2022)	Compulsory	1.
Bachelor, 1-Subject, Electrical Engineering and Business Management, (Version 2022)	Compulsory	1.

↑

Module Name	Module Code
Automatic Control	etit1011-01a
Module Coordinator	
Priv.-Doz. Dr. Alexander Schaum	
Organizer	
Department of Electrical and Information Engineering - Automatic Control	
Faculty	
Faculty of Engineering	
Examination Office	
Examination Office for Electrical Engineering and Information Technology	

ECTS Credits	7
Evaluation	Graded
Duration	One semester
Frequency	Only takes place during winter semesters
Workload per ECTS Credit	30 hours
Total Workload	210 hours
Contact Time	75 hours
Independent Study	135 hours
Teaching Language	German

Entry Requirements as Stated in the Examination Regulations

- Fundamentals of Electrical Engineering I (Module etit1001-01a)

Recommended Requirements

- Signals and Systems I (Module etit1005-01a)
- Mathematics for Engineering Sciences I - II (Modules mathMIng1-01a, mathMIng2-01a and mathMIng3-01a)

Module Courses

Course Type	Course Name	Compulsory/Optional	SWS
Lecture	Automatic Control	Compulsory	3
Exercise	Automatic Control	Compulsory	2

Examination(s)

Examination Name	Type of Examination	Evaluation	Compulsory / Optional	Weighting
Written Examination: Automatic Control	Written Examination	Graded	Compulsory	100

Course Content

- Introduction to automatic control engineering problems and the system concept
- Modeling of physical systems from mechanical engineering, electrical engineering, process engineering, biology
- Mathematical analysis of dynamical systems: solution existence and uniqueness, linearity and time invariance, linearization of nonlinear systems
- Linear dynamical systems in the time domain: transition matrix, state and similarity transformations, stability of linear systems
- Linear dynamical systems in the frequency domain: transfer function and transfer matrix, realization problem and canonical forms, input-output stability, continuous frequency response, poles and zeros, analysis of important control loop elements
- Analysis and design of control loops in the frequency domain: control loop structures, stability criteria, control design using the frequency characteristic method, control design using pole specification
- Analysis and design of control loops in the state space: controllability and observability, minimal realization, duality, design of state regulators, design of state observers, separation principle

Learning Outcome

Students are familiar with concepts and methods for the analysis and design of regulators and observers for linear systems in the frequency domain and in the state space. They can formulate and explain these and are able to derive more complex relationships based on them. They possess practical skills in system analysis and in the design of regulators and observers for linear systems in the frequency domain and in state space. They can evaluate and assess their behavior and properties.

Reading List

- T. Meurer: Regelungstechnik – Lecture notes.
- K. Aström, R. Murray: Feedback Systems, Princeton University Press, Princeton (NJ).
- C.T. Chen: Linear System Theory and Design, Oxford Univ. Press, New York.
- J.C. Doyle, B.A. Francis, A.R. Tannenbaum: Feedback Control Theory, New York, MacMillan.
- J. Lunze: Regelungstechnik I und II, Springer-Verlag, Berlin, Heidelberg.
- G. Ludyk: Theoretische Regelungstechnik 1, Springer-Verlag, Berlin Heidelberg.

Use	Compulsory / Optional	Semester
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2022)	Compulsory	5.
Bachelor, 1-Subject, Electrical Engineering and Business Management, (Version 2022)	Compulsory	5.

↑

Module Name	Module Code
Signals and Systems I	etit1005-01a
Module Coordinator	
Prof. Dr.-Ing. Gerhard Schmidt	
Organizer	
Department of Electrical and Information Engineering - Digital Signal Processing and System Theory	
Faculty	
Faculty of Engineering	
Examination Office	
Examination Office for Electrical Engineering and Information Technology	

ECTS Credits	7
Evaluation	Graded
Duration	One semester
Frequency	Only takes place during summer semesters
Workload per ECTS Credit	30 hours
Total Workload	210 hours
Contact Time	75 hours
Independent Study	135 hours
Teaching Language	German

Entry Requirements as Stated in the Examination Regulations

- Fundamentals of Electrical Engineering I (Module etit1001-01a)

Recommended Requirements

- Fundamentals of Electrical Engineering I and II (Modules etit1001-01a and etit1003-01a)
- Fundamentals of Circuit Technology (Module etit1004-01a)
- Mathematics for Engineering Sciences I - II (Modules mathMIng1-01a, mathMIng201a and math-MIng3-01a)

Module Courses

Course Type	Course Name	Compul-sory/Optional	SWS
Lecture	Signals and Systems I	Compulsory	3
Exercise	Signals and Systems I	Compulsory	2

Examination(s)

Examination Name	Type of Examination	Evaluation	Compulsory / Optional	Weighting
Written Examination: Signals and Systems I	Written Examina-tion	Graded	Compulsory	100

Course Content
Introduction Physical motivation of abstract signals and systems; classifications; determinate signals and their spectra: elementary signals, signal representation by linear combination of impulses, jumps, exponentials, Fourier series and discrete Fourier transform (DFT), Fourier transform, Laplace and z- transform. Input-output description of linear, shift-invariant, dynamical systems Elementary signal responses, convolution, transfer function and frequency response; fractional-rational transfer functions, poles and zeros, stability, special cases (zero phase, all-pass, minimum phase); examples of behavior in the "time" and "frequency" domains. Modulation as a specific shift-variant system; linear and nonlinear modulation, applications in communication technology, sampling as modulation, sampling theorem.
Learning Outcome
Students are able to classify systems and signals into groups or categories based on their properties (e.g. linear versus nonlinear systems, signals with limited versus unlimited energy). Based on these classifications, students are able to convert different forms of description for signals (time domain, frequency domain) and systems (impulse response, step response, state space, frequency response, transfer function) into each other, as well as to point out the advantages and disadvantages of the individual description forms. Furthermore, the students are able to recognize equivalent operations in the individual domains (a convolution in the time domain corresponds to a multiplication in the spectral domain).
Reading List
Up-to-date bibliography will be distributed in the lecture.

Use	**Compulsory / Optional**	**Semester**
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2022)	Compulsory	4.
Bachelor, 1-Subject, Electrical Engineering and Business Management, (Version 2022)	Compulsory	4.

↑

Module Name	Module Code
Signals and Systems II	etit1008-01a
Module Coordinator	
Prof. Dr.-Ing. Gerhard Schmidt	
Organizer	
Department of Electrical and Information Engineering - Digital Signal Processing and System Theory	
Faculty	
Faculty of Engineering	
Examination Office	
Examination Office for Electrical Engineering and Information Technology	

ECTS Credits	4
Evaluation	Graded
Duration	One semester
Frequency	Only takes place during winter semesters
Workload per ECTS Credit	30 hours
Total Workload	120 hours
Contact Time	45 hours
Independent Study	75 hours
Teaching Language	German

Entry Requirements as Stated in the Examination Regulations
• Fundamentals of Electrical Engineering I (Module etit1001-01a)
Recommended Requirements
• Signals and Systems I (Module etit1005-01a)

Module Courses

Course Type	Course Name	Compul-sory/Optional	SWS
Lecture	Signals and Systems II	Compulsory	2
Exercise	Signals and Systems II	Compulsory	1

Examination(s)

Examination Name	Type of Examination	Evaluation	Compulsory / Optional	Weighting
Written Examination: Signals and Systems II	Written Examina-tion	Graded	Compulsory	100

Course Content
Introduction Motivation of the advanced treatment of abstract signals and systems; stochastic signals and their spectra: primary descriptions (probability, probability density, univariant and multivariant, stationary and transient), secondary descriptions (expected values, moments, correlation / covariance), independence / uncorrelatedness / orthogonality, simple operations (summation, mapping), power density spectra, examples and special cases. Response of linear, shift-invariant, dynamical systems to random signals Moments and probabilities of system output; spectral description. Idealized linear systems Influence of different stylized systems (ideal bandpass filter, preemphasis, frequency response variations, etc.) on determinate as well as stochastic signals; special case "Hilbert transform", analytic signal, causality. State description Vectors of input, output and state variables, basic structure of linear systems, memory and states, signal-flow graphs (SFG), transmission, impulse response and transition matrices, elements and relations, stability, realizing SFG to transfer function and differential or difference equation. Quantization as a special nonlinear system, linear and nonlinear quantization, quantization noise, A/D and D/A converters.
Learning Outcome
Students know stochastic signals and are familiar with random processes and their typical forms of description (probability density, correlation, power spectral density). In addition, students have a deeper understanding of system descriptions in the state space including equivalent system transformations introduced there. Students have a basic understanding of sampling or digitization. They are also able to apply the knowledge they have learned to system analysis (e.g., passive circuit analysis) or system design (e.g., location or angle estimation using correlation analysis).
Reading List
Up-to-date bibliography will be distributed in the lecture.

Use	**Compulsory / Optional**	**Semester**
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2022)	Compulsory	5.
Bachelor, 1-Subject, Electrical Engineering and Business Management, (Version 2022)	Compulsory	5.

↑

Module Name	Module Code
Fundamentals of Information Technology	etit2002-01a
Module Coordinator	
Prof. Dr.-Ing. Peter Höher	
Organizer	
Department of Electrical and Information Engineering - Information and Coding Theory	
Faculty	
Faculty of Engineering	
Examination Office	
Examination Office for Electrical Engineering and Information Technology	

ECTS Credits	6
Evaluation	Graded
Duration	One semester
Frequency	Only takes place during summer semesters
Workload per ECTS Credit	30 hours
Total Workload	180 hours
Contact Time	60 hours
Independent Study	120 hours
Teaching Language	German

Entry Requirements as Stated in the Examination Regulations

- Fundamentals of Electrical Engineering I (Module etit1001-01a)

Recommended Requirements

- Signals and Systems I (Module etit1005-01a)
- Mathematics for Engineering Sciences I - III (Modules mathMIng1-01a, mathMIng2-01a und math-MIng3-01a)

Module Courses

Course Type	Course Name	Compul-sory/Optional	SWS
Lecture	Fundamentals of Information Technology	Compulsory	3
Exercise	Fundamentals of Information Technology	Compulsory	1

Examination(s)

Examination Name	Type of Examination	Evaluation	Compulsory / Optional	Weighting
Written Examination: Fundamentals of Information Technology	Written Examina-tion	Graded	Compulsory	100

Course Content

Basic concepts of information theory
- Information measures according to Hartley and Shannon, self-information, mutual information, entropy, conditional entropy, redundancy, typical sequences

Basic concepts of discrete probability theory
- Random variables, probability mass function, conditional mass probability function, joint probability mass function, statistical independence, chain rule of probability

Basic concepts of continuous probability theory
- Cumulative probability function, probability density function, differential entropy

Basics of source coding
- Memoryless sources, Shannon's source coding theorem, lossless source coding (Huffman coding, Willems algorithm)

Basics of channel coding
- Shannon’s channel coding theorem, channel capacity of the discrete time and continuous transmission channel

Basics of cryptology
- Classical cryptographic systems, Shannon's theory of secrecy, cryptographic systems with public keys (RSA system), authentication

Learning Outcome

The students are able to identify and explain the elementary concepts of information technology. They know the basic procedures of source coding (data compression), channel coding (protection against transmission errors) and cryptology (data security), and can explain them. In addition, the students are able to estimate the performance of coding systems on the basis of theoretical bounds.

Reading List

- Höher, P.A.: Grundlagen der digitalen Informationsübertragung, Springer-Vieweg Verlag, 2. Aufl., 2013
- Johannesson, R.: Informationsteorie - Grundlagen der (Tele)-Kommunikation, Addison-Wesley, 1992
- Cover T.M. und Thomas, J.A., Elements of Information Theory, John Wiley & Sons, 2. Auflage 2006

Use	Compulsory / Optional	Semester
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2022)	Compulsory	4.
Bachelor, 1-Subject, Electrical Engineering and Business Management, (Version 2022)	Compulsory	4.

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Name	Code
Technical In-depth Modules 22	
Organizer	
Faculty	
Faculty of Engineering	
Examination Office	

ECTS Credits	8
Evaluation	Graded

Use	Compulsory / Optional	Semester
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2022)	Compulsory	.

↑

Module Name	Module Code
Digital Audio Effects	etit6027-01a
Module Coordinator	
Prof. Dr.-Ing. Gerhard Schmidt	
Organizer	
Department of Electrical and Information Engineering - Digital Signal Processing and System Theory	
Faculty	
Faculty of Engineering	
Examination Office	
Examination Office for Electrical Engineering and Information Technology	

ECTS Credits	5
Evaluation	Graded
Duration	One semester
Frequency	Only takes place during summer semesters
Workload per ECTS Credit	30 hours
Total Workload	150 hours
Contact Time	60 hours
Independent Study	90 hours
Teaching Language	English

Module Courses			
Course Type	**Course Name**	**Compul-sory/Optional**	**SWS**
Lecture	Digital Audio Effects	Compulsory	2,5
Exercise	Digital Audio Effects	Compulsory	1,5

Examination(s)				
Examination Name	**Type of Examination**	**Evaluation**	**Compulsory / Optional**	**Weighting**
Oral Examination: Digital Audio Effects	Oral Examination	Graded	Compulsory	100

Course Content

During the lecture and the exercises basic procedures of digital audio effects should be acquainted. In particular, these are methods for audio equalizing, compression, reverberation, changing sampling rate and audio distortion. MATLAB is used for demonstration of the algorithms. The course includes a short review of digital signal processing and all the audio effects methods are embedded in this mathematical framework.

Topic overview

Digital signal processing - summary

- Ordered sequences of numbers & Difference equations
- Linear systems
- Discrete Fourier transform & Z-transform
- Transfer functions
- Correlation & Power spectra
- Fast convolution & DFT filter bank

Digital filters

- A, B,C, R468 weighting filters
- Equalizer
- Sampling rate conversion
- Non-linear distortion

Dynamic compression

- Fullband
- Multiband
- De-esser

Room acoustics and reverberation

- Impulse response measurement
- Artificial reverberation

Time scaling and pitch shift

- SOLA & PSOLA
- Phase Vocoder

Learning Outcome

Students are familiar with audio effects and have listening experience about how audio effects sound. They have an in-depth understanding of the theoretical, mathematical background. Furthermore, they can do literature research on related topics.

Reading List

- Zölzer, U.: Digital Audio Effects, John Wiley & Sons, 2011
- Zölzer, U.: Digital Audio Signal Processing, John Wiley & Sons, 2008
- Zölzer, U.: Digitale Audiosignalverarbeitung, Vieweg+Teubner Verlag, 2005
- Smith, J.O.: Introduction to Digital Filters: with Audio Applications, W3K Publishing,2007
- Smith, J.O.: Mathematics of the Discrete Fourier Transform (DFT): with audio Applications, De Gruyter Saur,2013
- Smith, J.O.: Spectral Audio Signal Processing, W3K Publishing,2011
- Dickreiter, M.: Handbuch der Tontechnik, De Gruyter Saur, 2013

Use	Compulsory / Optional	Semester
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2022)	Optional	1.
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2017)	Optional	1.
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2016)	Optional	1.
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2015)	Optional	1.
Bachelor, 1-Subject, Electrical Engineering and Business Management, (Version 2022)	Optional	1.
Bachelor, 1-Subject, Electrical Engineering and Business Management, (Version 2017)	Optional	1.
Bachelor, 1-Subject, Electrical Engineering and Business Management, (Version 2016)	Optional	1.
Bachelor, 1-Subject, Electrical Engineering and Business Management, (Version 2015)	Optional	1.
Master, 1-Subject, Electrical and Information Engineering, (Version 2022)	Optional	1.
Master, 1-Subject, Electrical and Information Engineering, Specialisation Automation and Control, (Version 2022)	Optional	1.
Master, 1-Subject, Electrical and Information Engineering, Specialisation Devices and Circuits, (Version 2022)	Optional	1.
Master, 1-Subject, Electrical and Information Engineering, Specialisation Digital Communications, (Version 2022)	Optional	1.
Master, 1-Subject, Electrical and Information Engineering, Specialisation Medical Applications, (Version 2022)	Optional	1.
Master, 1-Subject, Electrical and Information Engineering, Specialisation Power Electronics, Control and Communications in Energy Systems, (Version 2022)	Optional	1.
Master, 1-Subject, Electrical Engineering and Information Technology, (Version 2019)	Optional	1.
Master, 1-Subject, Electrical Engineering and Information Technology, Specialisation Automation and Control, (Version 2019)	Optional	1.
Master, 1-Subject, Electrical Engineering and Information Technology, Specialisation Devices and Circuits, (Version 2019)	Optional	1.
Master, 1-Subject, Electrical Engineering and Information Technology, Specialisation Digital Communications, (Version 2019)	Optional	1.
Master, 1-Subject, Electrical Engineering and Information Technology, Specialisation Medical Applications, (Version 2019)	Optional	1.
Master, 1-Subject, Electrical Engineering and Information Technology, Specialisation Power Electronics, Control and Communications in Energy Systems, (Version 2019)	Optional	1.
Master, 1-Subject, Electrical Engineering and Business Management, (Version 2022)	Optional	1.
Master, 1-Subject, Electrical Engineering and Business Management, (Version 2019)	Optional	1.

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Module Name	Module Code
Electromagnetic Compatibility	etit3004-01a
Module Coordinator	
Prof. Dr.-Ing. Ludger Klinkenbusch	
Organizer	
Department of Electrical and Information Engineeringomputational Electromagnetics	
Faculty	
Faculty of Engineering	
Examination Office	
Examination Office for Electrical Engineering and Information Technology	

ECTS Credits	4
Evaluation	Graded
Duration	One semester
Frequency	Only takes place during summer semesters
Workload per ECTS Credit	30 hours
Total Workload	120 hours
Contact Time	45 hours
Independent Study	75 hours
Teaching Language	German

Entry Requirements as Stated in the Examination Regulations

- Fundamentals of Electrical Engineering I (Module etit1001-01a)

Recommended Requirements

- Fundamentals of Electrical Engineering I and II (Modules etit1001-01a and etit1003-01a)
- Fundamentals of Circuit Technology (Module etit1004-01a)
- Electromagnetic Fields I (Module etit2001-01a)

Module Courses

Course Type	Course Name	Compul-sory/Optional	SWS
Lecture	Electromagnetic Compatibility	Compulsory	2
Exercise	Electromagnetic Compatibility	Compulsory	1

Examination(s)

Examination Name	Type of Examination	Evaluation	Compulsory / Optional	Weighting
Oral Examination: Electromagnetic Compa-tibility	Oral Examination	Graded	Compulsory	100

Course Content

Introduction
Terms and definitions, modeling, coupling types, classification of EMC problems

Shields and filters
Shielding for electrostatic and magnetostatic fields, for alternating magnetic fields and for electromagnetic waves, treatment of shield openings, frequency-selective filters, potential separators and voltage limiters, cable shielding

EMC measurement techniques
Measurement of emitted voltages and currents, measurement of emitted electromagnetic fields, antennas for EMC measurement purposes, susceptibility measurement for line- and radiation-borne disturbances

EMC of a system
Phases of EMC planning, modeling, systematic approach to complex systems

Electromagnetic compatibility of the environment - EMC
Problem definition, physiological effect, limit values

Learning Outcome

Students know what "electromagnetically compatible" means in both technical and legal terms. They are able to classify the significance of the problems associated with electromagnetic compatibility with regard to the rapid development of devices in electronics and communications engineering and to discuss the possible influence of electrotechnical products on the non-technical environment in a well-founded manner with regard to the technical details. Students are able to recognize possible EMC problems, apply methods to remedy such problems and develop associated procedures.

Reading List

- A. J. Schwab: Elektromagnetische Verträglichkeit, Springer, 1991
- K.H. Gonschorek, H. Singer (Hrsg.): Elektromagnetische Verträglicheit, Teubner, 1992
- F.M. Tesche, M.V. Ianoz, T. Karlsson: EMC Analysis Methods and Computational Methods, Wiley. 1997
- C.R. Paul: Introduction to Electromagnetic Compatibility, Wiley, 1992
- http://www.emf-portal.org

Use	Compulsory / Optional	Semester
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2022)	Optional	6.
Bachelor, 1-Subject, Electrical Engineering and Business Management, (Version 2022)	Optional	6.

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Module Name	Module Code
Power System Elements for Smart Grid and Renewable Energy Integration	etit3002-01a
Module Coordinator	
Prof. Dr.-Ing. Marco Liserre	
Organizer	
Department of Electrical and Information Engineering - Power Electronics	
Faculty	
Faculty of Engineering	
Examination Office	
Examination Office for Electrical Engineering and Information Technology	

ECTS Credits	4
Evaluation	Graded
Duration	One semester
Frequency	Only takes place during summer semesters
Workload per ECTS Credit	30 hours
Total Workload	120 hours
Contact Time	45 hours
Independent Study	75 hours
Teaching Language	German

Entry Requirements as Stated in the Examination Regulations

- Fundamentals of Electrical Engineering I (Module etit1001-01a)

Recommended Requirements

- Electrical Energy Technology (Module etit1007-01a)
- Automatic Control (Module etit1011-01a)

Module Courses

Course Type	Course Name	Compul-sory/Optional	SWS
Lecture	Power System Elements for Smart Grid and Renewable Energy Integration	Compulsory	2
Exercise	Power System Elements for Smart Grid and Renewable Energy Integration	Compulsory	1

Examination(s)

Examination Name	Type of Examination	Evaluation	Compulsory / Optional	Weighting
Written or Oral Examination: Power System Elements for Smart Grid and Renewable Energy Integration	Written or Oral Examination	Graded	Compulsory	100

Course Content

Smart grids, or intelligent power grids, are important to increase the integration of renewable energies. However, optimal management of the transmission and distribution network and the advanced control of the system that comes with it are needed. This course focuses on the fundamentals of the power grid and the smart grid concept.

Topic overview:
- Fundamentals of power grids and component modeling
- Load flow calculation
- Active and reactive power control, control of generation facilities
- Distribution networks and HVDC
- Economic basics
- The electricity market
- System security and ancillary services

Learning Outcome

The students have basic knowledge in the field of power grids, smart grids and the electricity market. They can perform an analysis of the power grid with regard to increasing the integration of renewable energies. The students can model the electrical components of the power grid and calculate the system state.

Reading List

- J. Duncan Glover, Mulukutla S. Sarma, Thomas J. Overbye “Power System analysis and design”, Cengage Learning, 2012.
- William D. Stevenson “Elements Of Power System Analysis”, McGraw-Hill, 1982
- Bergen, Arthur R., and Vijay Vittal. Power Systems Analysis. 2nd ed. Upper Saddle River, NJ: Prentice Hall, 2000.
- Gómez-Expósito, A., Conejo, A.J., & Cañizares, C. (Eds.). (2009). Electric Energy Systems: Analysis and Operation (1st ed.). CRC Press.
- David Infield and Leon Freris, “Renewable Energy in Power Systems”, John Wiley & Sons, 2019

Use	Compulsory / Optional	Semester
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2022)	Optional	6.
Bachelor, 1-Subject, Electrical Engineering and Business Management, (Version 2022)	Optional	6.

↑

Module Name	Module Code
Elements of Electric Drives for e-mobility	etit3003-01a
Module Coordinator	
Prof. Dr.-Ing. Marco Liserre	
Organizer	
Department of Electrical and Information Engineering - Power Electronics	
Faculty	
Faculty of Engineering	
Examination Office	
Examination Office for Electrical Engineering and Information Technology	

ECTS Credits	4
Evaluation	Graded
Duration	One semester
Frequency	Only takes place during summer semesters
Workload per ECTS Credit	30 hours
Total Workload	120 hours
Contact Time	45 hours
Independent Study	75 hours
Teaching Language	English

Entry Requirements as Stated in the Examination Regulations

- Fundamentals of Electrical Engineering I (Module etit1001-01a)

Recommended Requirements

- Electrical Energy Technology (Module etit1007-01a)
- Automatic Control (Module etit1011-01a)

Module Courses

Course Type	Course Name	Compul-sory/Optional	SWS
Lecture	Elements of Electric Drives for e-mobility	Compulsory	2
Exercise	Elements of Electric Drives for e-mobility	Compulsory	1

Examination(s)

Examination Name	Type of Examination	Evaluation	Compulsory / Optional	Weighting
Written or Oral Examination: Elements of Electric Drives for e-mobility	Written or Oral Examination	Graded	Compulsory	100

Course Content

- Basic knowledge of electric drives
- Configurations of electrical drives
- Design of electric drives for electric vehicles
- Basics about power converters and modulation for DC machines
- Model and Control of DC machines
- Knowledge of the power train of electric vehicles

Learning Outcome

The students are familiar with the basics of electrical drives, power converters and the power train of electric vehicles. They can describe the advantages and disadvantages of various technologies for electric vehicles and hybrid vehicles, calculate the underlying physical phenomena, and differentiate between different technical solutions. They can also explain models for DC machines, and implement appropriate regulators.

Reading List

- I. Boldea, S.A. Nasar, Electric Drives, 2004
- N. Mohan, Electric drives: an integrative approach, 2003
- Mehrdad Ehsani, Modern Electric Drives, Hybrid Electric and Fuel Cell Vehicles, CRC Press, 2005
- Ned Mohan, “Electric Machines and Drives: A First Course”, Wiley 2012
- Werner Leonhard, “Control of electric drives”, Springer 2001

Use	Compulsory / Optional	Semester
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2022)	Optional	5.
Bachelor, 1-Subject, Electrical Engineering and Business Management, (Version 2022)	Optional	5.

↑

Module Name	Module Code
Fundamentals of Electronic Device Fabrication Technology	etit5006-01a
Module Coordinator	
Prof. Dr. Hermann Kohlstedt	
Organizer	
Department of Electrical and Information Engineering - Nano Electronics	
Faculty	
Faculty of Engineering	
Examination Office	
Examination Office for Electrical Engineering and Information Technology	

ECTS Credits	5
Evaluation	Graded
Duration	One semester
Frequency	Only takes place during winter semesters
Workload per ECTS Credit	30 hours
Total Workload	150 hours
Contact Time	45 hours
Independent Study	105 hours
Teaching Language	English

Recommended Requirements

- Basics in Electronics
- Materials Science Lecture

Module Courses

Course Type	Course Name	Compul-sory/Optional	SWS
Lecture	Fundamentals of Electronic Device Fabrication Tech-nology	Compulsory	2
Exercise	Fundamentals of Electronic Device Fabrication Tech-nology	Compulsory	1

Examination(s)

Examination Name	Type of Examination	Evaluation	Compulsory / Optional	Weighting
Written or Oral Examination: Fundamentals of Electronic Device Fabrication Techno-logy	Written or Oral Examination	Graded	Compulsory	100

Course Content

Vacuum physics and vaccum technology
Basics of film growth and preconditions

Deposition technology
Evaporation, dc and rf sputtering, metal organic vapor deposition (MOCVD), pulsed Laser deposition (PLD), molecular beam epitaxy, Langmuir-Blodgett technique, nanoimprint techniques, bottom-up techniques

Etching
Wet and dry etching, plasma etching, reactive ion etching, ion beam etching including mass spectrometry

Lithography
Optical and e-beam lithography, photo resist, resolution

CMOS technology
Scaling laws, strained silicon, silicon on insulator (SOI), finFET, beyond CMOS

Learning Outcome

Students can describe essential and fundamentals in thin film technology and electronics device fabrication techniques. They are able to dimension a vacuum system in dependency of the goal, classificate different deposition, etching and lithography systems and decide which technology fits best to certain material class and electronics device. Students are able to classify process flows and estimation of their degree of complexity.

Reading List

- Scriptum of the lecture available on the Kiel University OLAT learning platform
- Fundamentals of Microfabrication, CRC Press, Marc Madou

Use	Compulsory / Optional	Semester
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2022)	Optional	1.
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2017)	Optional	1.
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2016)	Optional	1.
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2015)	Optional	1.
Bachelor, 1-Subject, Electrical Engineering and Business Management, (Version 2022)	Optional	1.
Bachelor, 1-Subject, Electrical Engineering and Business Management, (Version 2017)	Optional	1.
Bachelor, 1-Subject, Electrical Engineering and Business Management, (Version 2016)	Optional	1.
Bachelor, 1-Subject, Electrical Engineering and Business Management, (Version 2015)	Optional	1.
Master, 1-Subject, Electrical and Information Engineering, (Version 2022)	Optional	1.
Master, 1-Subject, Electrical and Information Engineering, Specialisation Automation and Control, (Version 2022)	Optional	1.
Master, 1-Subject, Electrical and Information Engineering, Specialisation Devices and Circuits, (Version 2022)	Optional	1.
Master, 1-Subject, Electrical and Information Engineering, Specialisation Digital Communications, (Version 2022)	Optional	1.
Master, 1-Subject, Electrical and Information Engineering, Specialisation Medical Applications, (Version 2022)	Optional	1.
Master, 1-Subject, Electrical and Information Engineering, Specialisation Power Electronics, Control and Communications in Energy Systems, (Version 2022)	Optional	1.
Master, 1-Subject, Electrical Engineering and Information Technology, (Version 2019)	Optional	1.
Master, 1-Subject, Electrical Engineering and Information Technology, Specialisation Automation and Control, (Version 2019)	Optional	1.
Master, 1-Subject, Electrical Engineering and Information Technology, Specialisation Devices and Circuits, (Version 2019)	Optional	1.
Master, 1-Subject, Electrical Engineering and Information Technology, Specialisation Digital Communications, (Version 2019)	Optional	1.
Master, 1-Subject, Electrical Engineering and Information Technology, Specialisation Medical Applications, (Version 2019)	Optional	1.
Master, 1-Subject, Electrical Engineering and Information Technology, Specialisation Power Electronics, Control and Communications in Energy Systems, (Version 2019)	Optional	1.
Master, 1-Subject, Electrical Engineering and Business Management, (Version 2022)	Optional	1.
Master, 1-Subject, Electrical Engineering and Business Management, (Version 2019)	Optional	1.

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Module Name	Module Code
Fundamentals of Analog Integrated Circuits	etit3005-01a
Module Coordinator	
Prof. Dr. Robert Rieger	
Organizer	
Department of Electrical and Information Engineering - Networked Electronic Systems	
Faculty	
Faculty of Engineering	
Examination Office	
Examination Office for Electrical Engineering and Information Technology	

ECTS Credits	4
Evaluation	Graded
Duration	One semester
Frequency	Takes place every semester
Workload per ECTS Credit	30 hours
Total Workload	120 hours
Contact Time	45 hours
Independent Study	75 hours
Teaching Language	German

Entry Requirements as Stated in the Examination Regulations

- Fundamentals of Electrical Engineering I (Module etit1001-01a)

Recommended Requirements

- Fundamentals of Electrical Engineering II (Module etit1003-01a)
- Fundamentals of Circuit Technology (Module etit1004-01a)
- Electronic Devices (Module etit1006-01a)

Module Courses

Course Type	Course Name	Compul-sory/Optional	SWS
Lecture	Fundamentals of Analog Integrated Circuits	Compulsory	1
Exercise	Fundamentals of Analog Integrated Circuits	Compulsory	2

Examination(s)

Examination Name	Type of Examination	Evaluation	Compulsory / Optional	Weighting
Oral Examination or Presentation or Assi-gnment: Fundamentals of Analog Integra-ted Circuits	Other	Graded	Compulsory	100

Course Content
• Advantages and disadvantages of integrated circuits compared to discrete structures • Basics of modeling for circuit simulation • Description of channel length modulation in MOS transistors and the Early effect of the BJT • Basic integrated circuits: Current mirror, cascode circuit, inverter, common-source amplifier, differential pair • Analysis of basic circuits regarding noise, AC and DC behavior • Layout of analog integrated circuits: Basic rules, parasitic effects • Simulation and layout in Cadence Design Systems
Learning Outcome
The students know the basics of modeling for circuit simulation and the fundamental rules of analog circuit layout. Students are able to analyze given basic circuits with regard to noise, AC and DC and behavior and to numerically simulate the temporal signal course. Students are able to carry out simulation and layout of integrated circuits in Cadence Design Systems.
Reading List
• Integrierte Schaltungen, K.-H. Cordes, A. Waag, N. Heuck, Pearson Studium Verlag, 2011

Use	**Compulsory / Optional**	**Semester**
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2022)	Optional	5.
Bachelor, 1-Subject, Electrical Engineering and Business Management, (Version 2022)	Optional	5.

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Module Name	Module Code
Electrical Power Devices	etit3007-01a
Module Coordinator	
Prof. Dr.-Ing. Holger Kapels	
Organizer	
Department of Electrical and Information Engineering - Electrical Power Devices	
Faculty	
Faculty of Engineering	
Examination Office	
Examination Office for Electrical Engineering and Information Technology	

ECTS Credits	4
Evaluation	Graded
Duration	One semester
Frequency	Only takes place during summer semesters
Workload per ECTS Credit	30 hours
Total Workload	120 hours
Contact Time	45 hours
Independent Study	75 hours
Teaching Language	German

Entry Requirements as Stated in the Examination Regulations

- Fundamentals of Electrical Engineering I (Module etit1001-01a)

Module Courses

Course Type	Course Name	Compul-sory/Optional	SWS
Lecture	Electrical Power Devices	Compulsory	2
Exercise	Electrical Power Devices	Compulsory	1

Examination(s)

Examination Name	Type of Examination	Evaluation	Compulsory / Optional	Weighting
Written or Oral Examination: Electrical Power Devices	Written or Oral Examination	Graded	Compulsory	100

Course Content
• Semiconductor physical fundamentals, pn junction • Power diodes • Power transistors (power MOSFETs, superjunction MOSFETs, IGBTs (including RB-IGBTs, RCIGBTs)) • Thyristors (GTOs, IGCTs) • Wide-bandgap power semiconductors (SiC diodes, -JFETs, -MOSFETs), GaN (normally-on, -off HEMTs) • Control and thermal design
Learning Outcome
The students know the most important modern power semiconductor components. They know the structure, the mode of operation as well as the characteristics and the limits of the components. The students are able to design individual power semiconductors and are familiar with important dimensioning rules. The students are able to solve typical problems in the design of power semiconductors.
Reading List
• Lutz, J.: Halbleiter-Leistungsbauelemente, Springer Vieweg, 2012 • Lutz, J., Schlangenotto, H., Scheuermann, U., De Doncker, R.: Semiconductor Power Devices, Springer, 2011 • Baliga, B.J.: Fundamentals of Power Semiconductor Devices, Springer, 2008

Use	**Compulsory / Optional**	**Semester**
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2022)	Optional	6.
Bachelor, 1-Subject, Electrical Engineering and Business Management, (Version 2022)	Optional	6.

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Module Name	Module Code
High-Frequency Measurement Techniques	etit3008-01a
Module Coordinator	
Dr.-Ing. Frank Daschner	
Organizer	
Department of Electrical and Information Engineering - Microwave Engineering	
Faculty	
Faculty of Engineering	
Examination Office	
Examination Office for Electrical Engineering and Information Technology	

ECTS Credits	4
Evaluation	Graded
Duration	One semester
Frequency	Only takes place during summer semesters
Workload per ECTS Credit	30 hours
Total Workload	120 hours
Contact Time	45 hours
Independent Study	75 hours
Teaching Language	German

Entry Requirements as Stated in the Examination Regulations

- Fundamentals of Electrical Engineering I (Module etit1001-01a)

Recommended Requirements

- Microwave Engineering I (Module etit1010-01a)
- Microwave Engineering II (Module etit2005-01a)

Module Courses

Course Type	Course Name	Compul-sory/Optional	SWS
Lecture	High-Frequency Measurement Techniques	Compulsory	2
Exercise	High-Frequency Measurement Techniques	Compulsory	1

Examination(s)

Examination Name	Type of Examination	Evaluation	Compulsory / Optional	Weighting
Written or Oral Examination: High-Frequency Measurement Techniques	Written or Oral Examination	Graded	Compulsory	100

Course Content

- Detectors
- Mixer
- Scalar quadrupole measurement
- Vector network analyzers
- Frequency measurement
- Spectrum analyzers
- Time domain measurements

Learning Outcome

The students are familiar with measurement tasks that occur specifically in high-frequency technology. They know how the measurement methods used to solve them work and can explain them. The students are familiar with the measuring instruments used in high-frequency technology. They can select, assemble and use the appropriate measuring equipment for a given measurement problem. The students are able to estimate the measurement accuracies for given measurement parameters.

Reading List

- F. Daschner: Vorlesungsumdruck Hochfrequenz-Messtechnik, CAU Kiel, 2016.
- B. Schiek: Messsysteme der Hochfrequenztechnik, Hüthig, Heidelberg, 1984.
- C. Rauscher: Grundlagen der Spektrumanalyse, Rohde und Schwarz, München, 2007.
- M. Hiebel: Grundlagen der vektoriellen Netzwerkanalyse, Rohde und Schwarz, München, 2006.

Use	Compulsory / Optional	Semester
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2022)	Optional	6.
Bachelor, 1-Subject, Electrical Engineering and Business Management, (Version 2022)	Optional	6.

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Module Name	Module Code
Identification and Estimation	etit3009-01a
Module Coordinator	
Priv.-Doz. Dr. Alexander Schaum	
Organizer	
Department of Electrical and Information Engineering - Automatic Control	
Faculty	
Faculty of Engineering	
Examination Office	
Examination Office for Electrical Engineering and Information Technology	

ECTS Credits	4
Evaluation	Graded
Duration	One semester
Frequency	Only takes place during summer semesters
Workload per ECTS Credit	30 hours
Total Workload	120 hours
Contact Time	45 hours
Independent Study	75 hours
Teaching Language	English

Entry Requirements as Stated in the Examination Regulations

- Fundamentals of Electrical Engineering I (Module etit1001-01a)

Recommended Requirements

- Signals and Systems I (Module etit1005-01a)
- Mathematics for Engineering Sciences I – III (Modules mathMIng1-01a, mathMIng2-01a and mathMIng3-01a)
- Automatic Control (Module etit1011-01a)

Module Courses

Course Type	Course Name	Compulsory/Optional	SWS
Lecture	Identification and Estimation	Compulsory	2
Exercise	Identification and Estimation	Compulsory	1

Examination(s)

Examination Name	Type of Examination	Evaluation	Compulsory / Optional	Weighting
Oral Examination: Identification and Estimation	Oral Examination	Graded	Compulsory	100

Course Content

This module provides an introduction to the fundamental concepts used in model-based data analysis for system monitoring, prediction and control purposes. In particular, the following contents are covered:

- Introduction to fundamental concepts for system identification and state estimation
- State-space approaches for system identification
- Analysis of observability and detectability of linear state-space models
- Design of linear observers and optimal state estimators (Kalman-Bucy and Kalman Filters)

Learning Outcome

Students can explain the fundamental concepts of system identification and estimation, and their importance in the context of system monitoring and control. They are able to use the basic approaches to system identification using continuous and discrete-time state-space models in a deterministic and stochastic framework, in combination with least squares or maximum likelihood techniques. The students are able to design and evaluate system models together with linear observers or Kalman filters, for use in data analysis and state estimation.

Reading List

- K. J. Keesman, System Identification: An introduction, Springer-Verlag, London, 2011
- A. Gelb, Applied Optimal Estimation, MIT Press, 2001
- T. Kailath, Linear Systems, Prentice-Hall, 1980
- O. Loffeld, Estimationstheorie 1 und 2, Oldenburg Verlag, 1990.

Use	Compulsory / Optional	Semester
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2022)	Optional	6.
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2017)	Optional	6.
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2016)	Optional	6.
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2015)	Optional	6.
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2014)	Optional	6.
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2010)	Optional	6.
Bachelor, 1-Subject, Electrical Engineering and Business Management, (Version 2022)	Optional	6.
Bachelor, 1-Subject, Electrical Engineering and Business Management, (Version 2017)	Optional	6.
Bachelor, 1-Subject, Electrical Engineering and Business Management, (Version 2016)	Optional	6.
Bachelor, 1-Subject, Electrical Engineering and Business Management, (Version 2015)	Optional	6.
Bachelor, 1-Subject, Electrical Engineering and Business Management, (Version 2014)	Optional	6.
Bachelor, 1-Subject, Electrical Engineering and Business Management, (Version 2010)	Optional	6.

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Module Name	Module Code
Introduction to Low-power CMOS System Design	etit5017-01a
Module Coordinator	
Prof. Dr. Robert Rieger	
Organizer	
Department of Electrical and Information Engineering - Networked Electronic Systems	
Faculty	
Faculty of Engineering	
Examination Office	
Examination Office for Electrical Engineering and Information Technology	

ECTS Credits	5
Evaluation	Graded
Duration	One semester
Frequency	Only takes place during summer semesters
Workload per ECTS Credit	30 hours
Total Workload	150 hours
Contact Time	45 hours
Independent Study	105 hours
Teaching Language	English

Recommended Requirements

- Knowledge of MOSFET operating principles, familiarity with basic circuit analysis methods
- Communications (Module etit-114)
- Signals and Systems I and II (Modules etit-104 and etit-108)

Module Courses

Course Type	Course Name	Compul-sory/Optional	SWS
Lecture	Introduction to Low-power CMOS System Design	Compulsory	2
Exercise	Introduction to Low-power CMOS System Design	Compulsory	1

Examination(s)

Examination Name	Type of Examination	Evaluation	Compulsory / Optional	Weighting
Written Examination or Online-Test: Intro-duction to Low-power CMOS System Design	Other	Graded	Compulsory	100

Course Content

This course covers basic aspects of low-power system design with a focus on portable, battery-powered applications. Based on the understanding that power consumption must be optimized on all design levels (device, circuit, architecture), special attention is paid to the discussion of low-power CMOS circuit blocks (circuit and architecture level). Starting with the digital circuits, students will analyze the dynamic power consumption of the inverter as a first example and will be able to extend the results to more general combinatorial circuits. Students will gain an understanding of analog circuits for voltage conversion (LDO, principle of DC-DC conversion) and switched-capacitor amplifier circuits with respect to functionality and power consumption. They are able to analyze the operation of the circuits at the circuit level. Students will know about related challenges in low-power design (e.g. current mirrors for low voltage operation and circuit noise).
In the accompanying exercise unit, students simulate circuit examples on the computer and compare with the analytical results from the lecture. They gain the foundation to be able to estimate circuit performance using simplified models for hand calculation.

Learning Outcome

Students understand the essential concepts for power optimization of digital and analog circuits on all design levels (device, circuit, architecture). They are familiar with strategies for low-power circuit design and can apply them. The students become familiar with the operating principles of selected essential integrated circuits (Switched-capacitor amplifiers, digital gates, voltage converters, etc.) and are able to analyze the circuits and determine their key design parameters.

Reading List

- Lecture handouts, including course slides.
- J. K. Fiorenza, T. Sepke, P. Holloway, C. G. Sodini, and H.-S. Lee, “Comparator-based switched-capacitor circuits for scaled CMOS technologies,” IEEE J. Solid-State Circuits, vol. 41, no. 12, pp. 2658–2668, Dec. 2006.
- Behzad Razavi, Design of Analog CMOS Integrated Circuits (English), McGraw Hill Book Co., September 2000.

Use	Compulsory / Optional	Semester
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2022)	Optional	1.
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2017)	Optional	1.
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2016)	Optional	1.
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2015)	Optional	1.
Bachelor, 1-Subject, Electrical Engineering and Business Management, (Version 2022)	Optional	1.
Bachelor, 1-Subject, Electrical Engineering and Business Management, (Version 2017)	Optional	1.
Bachelor, 1-Subject, Electrical Engineering and Business Management, (Version 2016)	Optional	1.
Bachelor, 1-Subject, Electrical Engineering and Business Management, (Version 2015)	Optional	1.
Master, 1-Subject, Electrical and Information Engineering, (Version 2022)	Optional	1.
Master, 1-Subject, Electrical and Information Engineering, Specialisation Automation and Control, (Version 2022)	Optional	1.
Master, 1-Subject, Electrical and Information Engineering, Specialisation Devices and Circuits, (Version 2022)	Optional	1.
Master, 1-Subject, Electrical and Information Engineering, Specialisation Digital Communications, (Version 2022)	Optional	1.
Master, 1-Subject, Electrical and Information Engineering, Specialisation Medical Applications, (Version 2022)	Optional	1.
Master, 1-Subject, Electrical and Information Engineering, Specialisation Power Electronics, Control and Communications in Energy Systems, (Version 2022)	Optional	1.
Master, 1-Subject, Electrical Engineering and Information Technology, (Version 2019)	Optional	1.
Master, 1-Subject, Electrical Engineering and Information Technology, Specialisation Automation and Control, (Version 2019)	Optional	1.
Master, 1-Subject, Electrical Engineering and Information Technology, Specialisation Devices and Circuits, (Version 2019)	Optional	1.
Master, 1-Subject, Electrical Engineering and Information Technology, Specialisation Digital Communications, (Version 2019)	Optional	1.
Master, 1-Subject, Electrical Engineering and Information Technology, Specialisation Medical Applications, (Version 2019)	Optional	1.
Master, 1-Subject, Electrical Engineering and Information Technology, Specialisation Power Electronics, Control and Communications in Energy Systems, (Version 2019)	Optional	1.
Master, 1-Subject, Electrical and Information Engineering, (Version 2015)	Optional	1.
Master, 1-Subject, Electrical Engineering and Business Management, (Version 2022)	Optional	1.
Master, 1-Subject, Electrical Engineering and Business Management, (Version 2019)	Optional	1.

Module Name	Module Code
Noise in Communications and Measurement Systems	etit6013-01a
Module Coordinator	
Prof. Dr.-Ing. Michael Höft	
Organizer	
Department of Electrical and Information Engineering - Microwave Engineering	
Faculty	
Faculty of Engineering	
Examination Office	
Examination Office for Electrical Engineering and Information Technology	

ECTS Credits	5
Evaluation	Graded
Duration	One semester
Frequency	Only takes place during summer semesters
Workload per ECTS Credit	30 hours
Total Workload	150 hours
Contact Time	45 hours
Independent Study	105 hours
Teaching Language	English

Module Courses			
Course Type	**Course Name**	**Compul-sory/Optional**	**SWS**
Lecture	Noise in Communications and Measurement Systems	Compulsory	2
Exercise	Noise in Communications and Measurement Systems	Compulsory	1

Examination(s)				
Examination Name	**Type of Examination**	**Evaluation**	**Compulsory / Optional**	**Weighting**
Written or Oral Examination: Noise in Communications and Measurement Systems	Written or Oral Examination	Graded	Compulsory	100

Course Content

- Thermal noise
- Mathematical and system-oriented fundamentals
- Noise of linear one- and two-ports
- Measurement of noise parameters
- Noise of diodes / shot noise
- Parametric theory for noise calculations in mixer circuits

Learning Outcome

The students have an in-depth understanding of noise phenomena in linear and basic understanding of noise in nonlinear microwave circuits. They know sources of noise in microwave circuits. They can analyse noise performance of simple circuits and components by applying the mathematical and system-oriented fundamentals. They can explain how measurements of noise parameters are performed and can point out where sources of errors exist in related setups. The students are able to calculate noise performance in mixer circuits by application of parametric theory. The students can determine the influences of noise phenomena on the sensitivity of communication and measurement systems.

Reading List

- B.Schiek, I. Rolfes, H.-J. Siweris; Noise in High-Frequency Circuits and Oscillators, Willey, 2006

Additional German Reading:

- B. Schiek, H-J Siweris: Rauschen in Hochfrequenzschaltungen, Hüthig, 1990.
- A. Blum, Elektronisches Rauschen, Stuttgart, B. G. Teubner, 1996
- H. Bittel, L. Storm: Rauschen. Eine Einführung zum Verständnis elektrischer Schwankungserscheinungen, Springer, 1971

Use	Compulsory / Optional	Semester
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2022)	Optional	1.
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2017)	Optional	1.
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2016)	Optional	1.
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2015)	Optional	1.
Bachelor, 1-Subject, Electrical Engineering and Business Management, (Version 2022)	Optional	1.
Bachelor, 1-Subject, Electrical Engineering and Business Management, (Version 2017)	Optional	1.
Bachelor, 1-Subject, Electrical Engineering and Business Management, (Version 2016)	Optional	1.
Bachelor, 1-Subject, Electrical Engineering and Business Management, (Version 2015)	Optional	1.
Master, 1-Subject, Electrical and Information Engineering, (Version 2022)	Optional	1.
Master, 1-Subject, Electrical and Information Engineering, Specialisation Automation and Control, (Version 2022)	Optional	1.
Master, 1-Subject, Electrical and Information Engineering, Specialisation Devices and Circuits, (Version 2022)	Optional	1.
Master, 1-Subject, Electrical and Information Engineering, Specialisation Digital Communications, (Version 2022)	Optional	1.
Master, 1-Subject, Electrical and Information Engineering, Specialisation Medical Applications, (Version 2022)	Optional	1.
Master, 1-Subject, Electrical and Information Engineering, Specialisation Power Electronics, Control and Communications in Energy Systems, (Version 2022)	Optional	1.
Master, 1-Subject, Electrical Engineering and Information Technology, (Version 2019)	Optional	1.
Master, 1-Subject, Electrical Engineering and Information Technology, Specialisation Automation and Control, (Version 2019)	Optional	1.
Master, 1-Subject, Electrical Engineering and Information Technology, Specialisation Devices and Circuits, (Version 2019)	Optional	1.
Master, 1-Subject, Electrical Engineering and Information Technology, Specialisation Digital Communications, (Version 2019)	Optional	1.
Master, 1-Subject, Electrical Engineering and Information Technology, Specialisation Medical Applications, (Version 2019)	Optional	1.
Master, 1-Subject, Electrical Engineering and Information Technology, Specialisation Power Electronics, Control and Communications in Energy Systems, (Version 2019)	Optional	1.
Master, 1-Subject, Electrical Engineering and Business Management, (Version 2022)	Optional	1.
Master, 1-Subject, Electrical Engineering and Business Management, (Version 2019)	Optional	1.

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Module Name	Module Code
Optical Communications	etit5014-01a
Module Coordinator	
Prof. Dr.-Ing. Stephan Pachnicke	
Organizer	
Department of Electrical and Information Engineering - Communications	
Faculty	
Faculty of Engineering	
Examination Office	
Examination Office for Electrical Engineering and Information Technology	

ECTS Credits	5
Evaluation	Graded
Duration	One semester
Frequency	Only takes place during summer semesters
Workload per ECTS Credit	30 hours
Total Workload	150 hours
Contact Time	60 hours
Independent Study	90 hours
Teaching Language	English

Module Courses			
Course Type	**Course Name**	**Compul-sory/Optional**	**SWS**
Lecture	Optical Communications	Compulsory	3
Exercise	Optical Communications	Compulsory	1

Examination(s)				
Examination Name	**Type of Examination**	**Evaluation**	**Compulsory / Optional**	**Weighting**
Written or Oral Examination: Optical Communications	Written or Oral Examination	Graded	Compulsory	100

Course Content

General Overview
Optical communications systems and important applications in telecommunications

Optical Transmission Channel
Fiber loss and dispersion, optical signals in single mode fiber, types of single mode fibers for communication purposes, system model of the single mode fiber, polarization and polarization mode dispersion, nonlinearity of the transmission fiber and numerical modelling, impact on digital signal transmission, split-step Fourier method, propagation modes in fibers, characteristics of multimode fibers

Optical Transmitters
Characterization of semiconductor lasers, materials, energy-band diagram, guidance of laser beams, design of lasers, Fabry-Perrot resonator, lasing condition, single-mode lasers, rate equations, power-current characteristic, direct modulation of lasers, laser-chirp, small-signal analysis, laser-frequency response

Optical Modulators
External modulators, electro-absorption modulator (EAM), Mach-Zehnder modulators (MZM), MZM model and characteristics, IQ-modulator (nested MZM)

Optical Receivers
Block diagram & model, photo diodes, noise performance, clock and data recovery

Optical Amplifiers
Principle of operation, main characteristics, noise performance

Optical Filters
Applications, Fiber Bragg gratings as filters, delay line filters, transfer functions

Optical Transmission Systems
System design, modulation formats, examples of typical applications

Learning Outcome

Students are able to describe fundamentals of optical communications and of the required optical and electronic components. They can discuss in detail the limiting effects of the optical communication channel based on a system-oriented view. They are able to explain the components used in transmitters and receivers of modern optical communication systems and can describe the major design aspects of optical transmission systems.

Reading List

- G. P. Agrawal, „Fiber-Optic Communication Systems“, ISBN: 0-471-21571-6
- I. P. Kaminow, T. Li, A. E. Willner, „Optical Fiber Telecommunications V B: Systems and Networks“, ISBN: 0-12-374172-1
- M. Seimetz: “High-Order Modulation for Optical Fiber Transmission”. Springer Series in Optical Sciences, 2009
- R. Ramaswami, K. N. Sivarajan, „Optical Networks“, ISBN: 1-55860-655-6

Use	Compulsory / Optional	Semester
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2022)	Optional	1.
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2017)	Optional	1.
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2016)	Optional	1.
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2015)	Optional	1.
Bachelor, 1-Subject, Electrical Engineering and Business Management, (Version 2022)	Optional	1.
Bachelor, 1-Subject, Electrical Engineering and Business Management, (Version 2017)	Optional	1.
Bachelor, 1-Subject, Electrical Engineering and Business Management, (Version 2016)	Optional	1.
Bachelor, 1-Subject, Electrical Engineering and Business Management, (Version 2015)	Optional	1.
Master, 1-Subject, Electrical and Information Engineering, (Version 2022)	Optional	1.
Master, 1-Subject, Electrical and Information Engineering, Specialisation Automation and Control, (Version 2022)	Optional	1.
Master, 1-Subject, Electrical and Information Engineering, Specialisation Devices and Circuits, (Version 2022)	Optional	1.
Master, 1-Subject, Electrical and Information Engineering, Specialisation Digital Communications, (Version 2022)	Optional	1.
Master, 1-Subject, Electrical and Information Engineering, Specialisation Medical Applications, (Version 2022)	Optional	1.
Master, 1-Subject, Electrical and Information Engineering, Specialisation Power Electronics, Control and Communications in Energy Systems, (Version 2022)	Optional	1.
Master, 1-Subject, Electrical Engineering and Information Technology, (Version 2019)	Optional	1.
Master, 1-Subject, Electrical Engineering and Information Technology, Specialisation Automation and Control, (Version 2019)	Optional	1.
Master, 1-Subject, Electrical Engineering and Information Technology, Specialisation Devices and Circuits, (Version 2019)	Optional	1.
Master, 1-Subject, Electrical Engineering and Information Technology, Specialisation Digital Communications, (Version 2019)	Optional	1.
Master, 1-Subject, Electrical Engineering and Information Technology, Specialisation Medical Applications, (Version 2019)	Optional	1.
Master, 1-Subject, Electrical Engineering and Information Technology, Specialisation Power Electronics, Control and Communications in Energy Systems, (Version 2019)	Optional	1.
Master, 1-Subject, Mathematics, (Version 2017)	Optional	1.
Master, 1-Subject, Mathematics, (Version 2007)	Optional	1.
Master, 1-Subject, Electrical Engineering and Business Management, (Version 2022)	Optional	1.
Master, 1-Subject, Electrical Engineering and Business Management, (Version 2019)	Optional	1.

Module Name	Module Code
Radar	etit3010-01a
Module Coordinator	
Dr.-Ing. Frank Daschner	
Organizer	
Department of Electrical and Information Engineering - Microwave Engineering	
Faculty	
Faculty of Engineering	
Examination Office	
Examination Office for Electrical Engineering and Information Technology	

ECTS Credits	4
Evaluation	Graded
Duration	One semester
Frequency	Only takes place during winter semesters
Workload per ECTS Credit	30 hours
Total Workload	120 hours
Contact Time	45 hours
Independent Study	75 hours
Teaching Language	German

Entry Requirements as Stated in the Examination Regulations

- Fundamentals of Electrical Engineering I (Module etit1001-01a)

Recommended Requirements

- Microwave Engineering I (Module etit1010-01a)
- Microwave Engineering II (Module etit2005-01a)

Module Courses

Course Type	Course Name	Compul-sory/Optional	SWS
Lecture	Radar	Compulsory	2
Exercise	Radar	Compulsory	1

Examination(s)

Examination Name	Type of Examination	Evaluation	Compulsory / Optional	Weighting
Written or Oral Examination: Radar	Written or Oral Examination	Graded	Compulsory	100

Course Content
Principle and radar types: radar equation, resolution and measurement accuracy, signal energy and noise, required signal-to-noise ratio, integration, radar techniques: continuous wave radar, Doppler radar, FMCW radar, pulse radar, pulse compression.
Learning Outcome
The students know the basics of radar system technology and the technical design of radar systems. The students are able to calculate the ranges and resolutions of radar systems. They know procedures for increasing the signal-to-noise ratio. They know how the most important radar methods work and their areas of application.
Reading List
• Daschner, F.; Höft, M.; Knöchel, R.: Radar, Vorlesungsumdruck, CAU Kiel, 2016. • Detlefsen, J.: Radartechnik, Springer, Berlin, 1989. • Ludloff, A.: Praxiswissen Radar und Radarsignalverarbeitung, Vieweg, 3. Auflage, Braunschweig, 2002. • Skolnik, M.: Radar Handbook, McGraw-Hill, 2. Auflage, New York, 1990.

Use	Compulsory / Optional	Semester
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2022)	Optional	6.
Bachelor, 1-Subject, Electrical Engineering and Business Management, (Version 2022)	Optional	6.

↑

Module Name	Module Code
Sensors	etit3011-01a
Module Coordinator	
Prof. Dr. Hermann Kohlstedt	
Organizer	
Department of Electrical and Information Engineering - Nano Electronics	
Faculty	
Faculty of Engineering	
Examination Office	
Examination Office for Electrical Engineering and Information Technology	

ECTS Credits	4
Evaluation	Graded
Duration	One semester
Frequency	Only takes place during summer semesters
Workload per ECTS Credit	30 hours
Total Workload	120 hours
Contact Time	45 hours
Independent Study	75 hours
Teaching Language	German

Entry Requirements as Stated in the Examination Regulations
• Fundamentals of Electrical Engineering I (Module etit1001-01a)
Recommended Requirements
• Fundamentals of Electrical Engineering II (Module etit1003-01a) • Fundamentals of Circuit Technology (Module etit1004-01a)

Module Courses

Course Type	Course Name	Compul-sory/Optional	SWS
Lecture	Sensors	Compulsory	2
Exercise	Sensors	Compulsory	1

Examination(s)

Examination Name	Type of Examination	Evaluation	Compulsory / Optional	Weighting
Written or Oral Examination: Sensors	Written or Oral Examination	Graded	Compulsory	100

Course Content

- Sensors in nature, examples: Structure and function of the eye and ear, magnetic field detection in animals, electric field detection in sharks, ultrasonic detection in bats.
- Temperature sensors: metal, semiconductors, hot and cold conductors, Seebeck effect
- Magnetic field sensors: Induction coil, Hall sensors, field plates, flux gates, AMR, GMR and TMR sensors, SQUIDs, magneto-optical sensors.
- Optical sensors: in the UV, visible and infrared range
- X-ray detectors
- Sound and ultrasonic sensors: piezoelectric sensors, sound sensors based on optical fibers
- Sound and ultrasonic transmitters and receivers
- Chemical and bio-sensors: Ion-sensitive FET (ISFET), gas sensors
- Lab-on a chip

Note: For the individual sensors, the underlying physical effects are always explained.

Learning Outcome

The students know the basic effects on which the individual sensors are based and can explain them. They know the sensitivity limits of the various sensors and can explain which influences are responsible for this. The students are able to select the correct sensor for a measurement task depending on the quantity to be measured, the sensitivity, the robustness and the costs.

Reading List

- Fundamentals of Microfabrication, CRC Press, Marc Madou
- Sensorik, W. Heywang, Halbleiterelektronik, Springer-Verlag, 1986
- K. Stahl, G. Miosaga, Infrarottechnik, Hüthig-Verlag 1986
- Sensoren, H.Schaumburg, B.G. Teubner Verlag,
- Sensortechnik, H.-R. Tränkler, E.Obermeier (Hrsg.), Springer Verlag,
- Mikrosensorik, Thomas Elbel, Vieweg- Verlag
- Sensors, W. Göpel, J. Hesse und J.N. Zemel, VCH Verlag
- Sensoren, G. Schanz, Hüthig-Verlag
- Halbleiter-Schaltungstechnik, U. Tietze u. Ch. Schenk, Springer Verlag

Use	Compulsory / Optional	Semester
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2022)	Optional	6.
Bachelor, 1-Subject, Electrical Engineering and Business Management, (Version 2022)	Optional	6.

↑

Module Name	Module Code
Wireless Communications	etit5016-01a
Module Coordinator	
Prof. Dr.-Ing. Peter Höher	
Organizer	
Department of Electrical and Information Engineering - Information and Coding Theory	
Faculty	
Faculty of Engineering	
Examination Office	
Examination Office for Electrical Engineering and Information Technology	

ECTS Credits	5
Evaluation	Graded
Duration	One semester
Frequency	Only takes place during summer semesters
Workload per ECTS Credit	30 hours
Total Workload	150 hours
Contact Time	45 hours
Independent Study	105 hours
Teaching Language	English

Module Courses			
Course Type	**Course Name**	**Compul-sory/Optional**	**SWS**
Lecture	Wireless Communications	Compulsory	2
Exercise	Wireless Communications	Compulsory	1

Examination(s)				
Examination Name	**Type of Examination**	**Evaluation**	**Compulsory / Optional**	**Weighting**
Written Examination: Wireless Communications	Written Examination	Graded	Compulsory	100

Course Content

Fundamentals: Classification of mobile radio systems, cellularization, cellular radio standards and evolutions, uplink and downlink, frequency bands, multi-user access, software-defined radio

Channel modeling: AWGN, Rayleigh/Rice fading, WSSUS channel model, Doppler and delay spread, discrete-time channel modeling

Digital modulation schemes: PAM, QAM, PSK, CPM/FSK, OFDM, detection algorithms, power/bandwidth diagram

Multi-user access techniques: FDMA, TDMA, CDMA, OFDMA, IDMA, NOMA, interference cancellation

MIMO systems: Space-time codes, spatial diversity, spatial multiplexing, beamforming, MIMO channel capacity, massive MIMO

Equalization and channel estimation: Maximum-likelihood sequence estimation, reduced-state sequence estimation, least-squares channel estimation, interpolative channel estimation

Cellular radio standards: GSM, UMTS, LTE and 5G system aspects, 6G design goals

Applications: Telephony, wireless Internet access, video streaming, massive IoT, massive MTC

Learning Outcome

The students acquire a basic knowledge about fundamentals in the field of digital radio. The students learn the basics of wireless baseband techniques. They are able to design fundamental baseband algorithms suitable for software-defined radio, and they are able to evaluate radio subsystems. They are familiar with different wireless radio standards and they understand their differences and commonalities.

Reading List

- E. Biglieri, R. Calderbank, A. Constantinides, A. Goldsmith, A. Paulraj, H.V. Poor: MIMO Wireless Comunications. Cambridge University Press, 2007.
- A. Goldsmith: Wireless Communications. Cambridge University Press, 2005.
- V. Kuehn: Wireless Communications over MIMO Channels. Wiley, 2006.
- A.F. Molisch: Wireless Communications. IEEE Press - Wiley, 2005.
- T.S. Rappaport: Wireless Communications - Principles & Practice. Prentice Hall, 1996.
- J.G. Proakis: Digital Communications. McGraw-Hill, 4th ed., 2001.
- R. Steele, L. Hanzo: Mobile Radio Communications. John Wiley & Sons, 2nd ed., 1999.
- G.L. Stueber: Principles of Mobile Communication. Kluwer Academic Publishers, 1996.
- D. Tse, P. Viswanath: Fundamentals of Wireless Communication. Cambridge University Press, 2005.

Additional German Reading:

- P.A. Höher: Grundlagen der digitalen Informationsübertragung. Springer-Vieweg, 2nd ed., 2013.

Use	Compulsory / Optional	Semester
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2022)	Optional	1.
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2017)	Optional	1.
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2016)	Optional	1.
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2015)	Optional	1.
Bachelor, 1-Subject, Electrical Engineering and Business Management, (Version 2022)	Optional	1.
Bachelor, 1-Subject, Electrical Engineering and Business Management, (Version 2017)	Optional	1.
Bachelor, 1-Subject, Electrical Engineering and Business Management, (Version 2016)	Optional	1.
Bachelor, 1-Subject, Electrical Engineering and Business Management, (Version 2015)	Optional	1.
Master, 1-Subject, Electrical and Information Engineering, (Version 2022)	Optional	1.
Master, 1-Subject, Electrical and Information Engineering, Specialisation Automation and Control, (Version 2022)	Optional	1.
Master, 1-Subject, Electrical and Information Engineering, Specialisation Devices and Circuits, (Version 2022)	Optional	1.
Master, 1-Subject, Electrical and Information Engineering, Specialisation Digital Communications, (Version 2022)	Optional	1.
Master, 1-Subject, Electrical and Information Engineering, Specialisation Medical Applications, (Version 2022)	Optional	1.
Master, 1-Subject, Electrical and Information Engineering, Specialisation Power Electronics, Control and Communications in Energy Systems, (Version 2022)	Optional	1.
Master, 1-Subject, Electrical Engineering and Information Technology, (Version 2019)	Optional	1.
Master, 1-Subject, Electrical Engineering and Information Technology, Specialisation Automation and Control, (Version 2019)	Optional	1.
Master, 1-Subject, Electrical Engineering and Information Technology, Specialisation Devices and Circuits, (Version 2019)	Optional	1.
Master, 1-Subject, Electrical Engineering and Information Technology, Specialisation Digital Communications, (Version 2019)	Optional	1.
Master, 1-Subject, Electrical Engineering and Information Technology, Specialisation Medical Applications, (Version 2019)	Optional	1.
Master, 1-Subject, Electrical Engineering and Information Technology, Specialisation Power Electronics, Control and Communications in Energy Systems, (Version 2019)	Optional	1.
Master, 1-Subject, Electrical Engineering and Business Management, (Version 2022)	Optional	1.
Master, 1-Subject, Electrical Engineering and Business Management, (Version 2019)	Optional	1.

↑

Name	Code
Lab Courses and Project	etit
Organizer	
Faculty	
Faculty of Engineering	
Examination Office	

Evaluation	Not graded

Use	Compulsory / Optional	Semester
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2022)	Compulsory	.

↑

Module Name	Module Code
Basic Laboratory Electrical Engineering	etit4002-01a
Module Coordinator	
Dipl.-Ing. Dr.-Ing. Michael Meißer	
Organizer	
Department of Electrical and Information Engineering	
Faculty	
Faculty of Engineering	
Examination Office	
Examination Office for Electrical Engineering and Information Technology	

ECTS Credits	5
Evaluation	Not graded
Duration	One semester
Frequency	Only takes place during winter semesters
Workload per ECTS Credit	30 hours
Total Workload	150 hours
Contact Time	37,5 hours
Independent Study	112,5 hours
Teaching Language	German

Recommended Requirements

- Mathematics for Engineering Sciences I – III (Modules mathMIng1-01a, mathMIng2-01a and math-MIng3-01a)
- Fundamentals of Electrical Engineering I and II (Modules etit1001-01a and etit1003-01a)
- Fundamentals of Circuit Technology (Module etit1004-01a)

Module Courses

Course Type	Course Name	Compul-sory/Optional	SWS
Practical exercise	Basic Laboratory Electrical Engineering	Compulsory	2,5

Examination(s)

Examination Name	Type of Examination	Evaluation	Compulsory / Optional	Weighting
Colloquia, Practical Tasks and Protocols: Basic Laboratory Electrical Engineering	Other	Not graded	Compulsory	100

Further Information on the Examination(s)

Colloquium before the start of each experiment, execution of experiments, protocols

Course Content
Within the framework of the basic practical course in electrical engineering (GPET), the students practically apply the theoretically imparted knowledge of the modules " Fundamentals of Electrical Engineering I and II" (etit1001-01a and etit1003-01a) as well as "Fundamentals of Circuit Technology" (etit1004-01a). In addition, they independently acquire further knowledge in order to be specifically prepared for the individual experiments and projects. The students are supported by impulse lectures and workshop-like courses. The experiments and project work take place partly in the laboratory, but also partly at home. For the work outside the laboratory, appropriate experiment sets are issued if necessary. The GPET teaching content includes: • Introduction to the evaluation and documentation of measurement results, the presentation of measurement results and the writing of scientific texts, • Conducting experiments on various topics in electrical engineering, • Development of software and hardware, • Conducting project-oriented experiments, group work and project management, • Introduction to the presentation of scientific findings.
Learning Outcome
The students are able to implement circuit diagrams and construction drawings and to examine setups by measurement. Students are able to graphically present measurement results in context and discuss them in comparison with theoretical considerations. They use printed and online knowledge resources to familiarize themselves with new topics. They can express themselves appropriately and comprehensibly in writing about their results. The students have experience in project work and are able to successfully complete tasks in teams. They can systematically develop a solution to a technical problem and evaluate it. Furthermore, they are able to design and build measuring systems and to design, manufacture and characterize electrical components.
Reading List
The experiment instructions and other documents are made available on the OLAT platform to all students enrolled in the course.

Use	**Compulsory / Optional**	**Semester**
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2022)	Compulsory	3.
Bachelor, 1-Subject, Electrical Engineering and Business Management, (Version 2022)	Compulsory	3.

↑

Module Name	Module Code
Project	etit4003-01a
Module Coordinator	
Organizer	
Department of Electrical and Information Engineering	
Faculty	
Faculty of Engineering	
Examination Office	
Examination Office for Electrical Engineering and Information Technology	

ECTS Credits	4
Evaluation	Not graded
Duration	One semester
Frequency	Takes place every semester
Workload per ECTS Credit	30 hours
Total Workload	120 hours
Contact Time	45 hours
Independent Study	75 hours

Module Courses			
Course Type	**Course Name**	**Compul-sory/Optional**	**SWS**
Lecture	Project	Compulsory	

Examination(s)				
Examination Name	**Type of Examination**	**Evaluation**	**Compulsory / Optional**	**Weighting**
Practical Task, Presentation and Written Report: Project	Other	Not graded	Compulsory	100

Course Content
The focus of the project work can be experimental (e.g. conception and set-up of a test set-up, execution of the experiments and their evaluation and assessment of the results) as well as theoretical (e.g. literature research and comparative assessment of known solution approaches for a new problem or development of new solution approaches and testing of their suitability by computer simulations).
Learning Outcome
The students are familiar with scientific work and can practically implement it. This includes literature research, project planning, development and implementation of solution approaches, data evaluation, result interpretation as well as the written and oral presentation of the results according to the scientific standard. The students are able to work successfully on tasks in teams.

Reading List
Appropriate literature is provided individually for each project.

Use	**Compulsory / Optional**	**Semester**
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2022)	Compulsory	6.

↑

Module Name	Module Code
Introductory Project Electrical Engineering	etit4001-01a
Module Coordinator	
Prof. Dr. Martina Gerken	
Organizer	
Department of Electrical and Information Engineering - Integrated Systems and Photonics	
Faculty	
Faculty of Engineering	
Examination Office	
Examination Office for Electrical Engineering and Information Technology	

ECTS Credits	1
Evaluation	Not graded
Duration	One semester
Frequency	Only takes place during winter semesters
Workload per ECTS Credit	30 hours
Total Workload	30 hours
Contact Time	30 hours
Teaching Language	German

Module Courses			
Course Type	**Course Name**	**Compul-sory/Optional**	**SWS**
Project	Introductory Project Electrical Engineering	Compulsory	2

Examination(s)				
Examination Name	**Type of Examination**	**Evaluation**	**Compulsory / Optional**	**Weighting**
Demonstration and Colloquium: Introduc-tory Project Electrical Engineering	Other	Not graded	Compulsory	100
Further Information on the Examination(s)				
Demonstration of the functioning metal detector and colloquium				

Course Content
In groups of five, metal detectors are built and compared with each other in a sensor challenge. The metal detector (eddy current measurement technology) is built on plug-in boards and controlled and evaluated with a microcontroller (Arduino). The characterization is done with the help of an oscilloscope. The main part of the time is devoted to practical group work. Instruction is provided through lectures, question and answer sessions, and material made available on an online learning portal.

Learning Outcome
Students have a more accurate idea of the engineering profession and an impression of the required study content. They are motivated for the lecture material of the first semesters, familiar with the Faculty of Engineering and networked with each other.
Reading List
Material is made available on an online learning platform at the start of the project.

Use	Compulsory / Optional	Semester
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2022)	Compulsory	1.
Bachelor, 1-Subject, Electrical Engineering and Business Management, (Version 2022)	Compulsory	1.

↑

Name	Code
Advanced Lab Courses	
Organizer	
Faculty	
Faculty of Engineering	
Examination Office	

Evaluation	Not graded

Use	Compulsory / Optional	Semester
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2022)	Compulsory	.

↑

Module Name	Module Code
B.Sc. Laboratory Embedded Signal Processing	etit4004-01a
Module Coordinator	
Prof. Dr.-Ing. Gerhard Schmidt	
Organizer	
Department of Electrical and Information Engineering - Digital Signal Processing and System Theory	
Faculty	
Faculty of Engineering	
Examination Office	
Examination Office for Electrical Engineering and Information Technology	

ECTS Credits	4
Evaluation	Not graded
Duration	One semester
Frequency	Only takes place during summer semesters
Workload per ECTS Credit	30 hours
Total Workload	120 hours
Contact Time	60 hours
Independent Study	60 hours
Teaching Language	German

Entry Requirements as Stated in the Examination Regulations

- Fundamentals of Electrical Engineering I (Module etit1001-01a)

Recommended Requirements

- Computer Science I (Modul Inf-I1-2FNF)
- Signals and Systems I (Module etit1005-01a)
- Signals and Systems II (Module etit1008-01a)

Module Courses

Course Type	Course Name	Compul-sory/Optional	SWS
Practical exercise	B.Sc. Laboratory Embedded Signal Processing	Compulsory	4

Examination(s)

Examination Name	Type of Examination	Evaluation	Compulsory / Optional	Weighting
Practical Tasks: B.Sc. Laboratory Embedded Signal Processing	Other	Not graded	Compulsory	100

Course Content

I. Introduction to the hardware used and the programming language
- Connecting the hardware
- Getting to know the programming environment
- Trying out program examples
- Visualization of the time signals

II. Implementation of an analysis filter bank
- Creating an analysis filter bank class
- Declaration of functions, parameters and signals
- Initialization of the declared functions, parameters and signals

III. Implementation of a synthesis filterbank
- Creating a synthesis filterbank class
- Declaration of functions, parameters and signals
- Initialization of the declared functions, parameters and signals
- Testing the interaction of the analysis and synthesis filter bank

IV. Implementation of convolution (in time and frequency domain)
- Declaration of functions, parameters and signals
- Initialization of declared functions, parameters and signals

V. Implementation of high-pass and band-pass filtering (in the frequency domain)

VI. Implementation of modulation (in the frequency domain)

VII. Implementation of single channel communication

VIII. introduction to noise cancellation
- Design of a processing chain
- Creating a class for noise cancellation
- Declaration of functions, parameters and signals

IX. Implementation of the designed noise cancellation modules
- Initialization of the declared functions, parameters and signals

X. Implementation of the combination of single-channel communication and noise cancellation

Learning Outcome

Students are familiar with various aspects of digital signal processing (digitalization of signals, transformations, different types of convolutional realizations as well as deterministic and statistical filter design methods) and are able to explain them. They are able to implement a complete digital signal processing chain on an embedded hardware platform in the programming language C or C++.

Reading List

Literature list is handed out in the course.

Use	Compulsory / Optional	Semester
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2022)	Optional	6.
Bachelor, 1-Subject, Electrical Engineering and Business Management, (Version 2022)	Optional	6.

↑

Module Name	Module Code
B.Sc. Laboratory Microwave Engineering	etit4005-01a
Module Coordinator	
Prof. Dr.-Ing. Michael Höft	
Organizer	
Department of Electrical and Information Engineering - Microwave Engineering	
Faculty	
Faculty of Engineering	
Examination Office	
Examination Office for Electrical Engineering and Information Technology	

ECTS Credits	4
Evaluation	Not graded
Duration	One semester
Frequency	Only takes place during summer semesters
Workload per ECTS Credit	30 hours
Total Workload	120 hours
Contact Time	45 hours
Independent Study	75 hours
Teaching Language	German

Entry Requirements as Stated in the Examination Regulations

- Fundamentals of Electrical Engineering I (Module etit1001-01a)

Recommended Requirements

- Microwave Engineering I (Modul etit1010-01a)
- Microwave Engineering II (Modul etit2005-01a)

Module Courses

Course Type	Course Name	Compul-sory/Optional	SWS
Practical exercise	B.Sc. Laboratory Microwave Engineering	Compulsory	3

Examination(s)

Examination Name	Type of Examination	Evaluation	Compulsory / Optional	Weighting
Colloquia, Practical Tasks and Protocols: B.Sc. Laboratory Microwave Engineering	Other	Not graded	Compulsory	100

Course Content

Experiments:
1. Network description and analysis in high-frequency technology
2. HF amplifier with field effect transistors
3. HF circuit design
4. Resonators in HF technology
5. Matching circuits
6. ASH receiver
7. Heterodyne receivers
8. HF components with HFSS
9. Radar systems and antennas

Learning Outcome

Students are familiar with measurement methods used in high-frequency technology and can explain them. They are able to select, assemble and operate suitable measuring equipment for a given measurement problem. The students are able to characterize and analyze high-frequency components and systems by means of measurements. They can also independently dimension modules using contemporary design software and subsequently assemble and measure these modules. Students will be able to dimension matching circuits, analyze the nonlinear behavior of amplifiers by measurement, know how important receiver circuits work, and generate antenna directional diagrams.

Reading List

- Höft, M.: Leitungstheorie, Vorlesungsumdruck, CAU Kiel, 2015.
- Höft, M.: Nichtlineare Schaltungen, Vorlesungsumdruck, CAU Kiel, 2015.
- Höft, M.: Hochfrequenztechnik - Antennen, Sender, Empfänger, Vorlesungsumdruck, CAU Kiel, 2015.
- Unger, H.-G.: Elektromagnetische Wellen auf Leitungen, Hüthig-Verlag, Heidelberg, 1996.
- Unger, H.-G.: Hochfrequenztechnik in Funk und Radar, Teubner, 1994.
- Voges, E.: Hochfrequenztechnik, Band 1 und Band 2, Hüthig-Verlag, 1986.

Use	Compulsory / Optional	Semester
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2022)	Optional	6.
Bachelor, 1-Subject, Electrical Engineering and Business Management, (Version 2022)	Optional	6.

↑

Module Name	Module Code
B.Sc. Laboratory Power Electronics	etit4006-01a
Module Coordinator	
Prof. Dr.-Ing. Marco Liserre	
Organizer	
Department of Electrical and Information Engineering - Power Electronics	
Faculty	
Faculty of Engineering	
Examination Office	
Examination Office for Electrical Engineering and Information Technology	

ECTS Credits	4
Evaluation	Not graded
Duration	One semester
Frequency	Only takes place during summer semesters
Workload per ECTS Credit	30 hours
Total Workload	120 hours
Contact Time	45 hours
Independent Study	75 hours
Teaching Language	German

Entry Requirements as Stated in the Examination Regulations

- Fundamentals of Electrical Engineering I (Module etit1001-01a)

Module Courses

Course Type	Course Name	Compul-sory/Optional	SWS
Practical exercise	B.Sc. Laboratory Power Electronics	Compulsory	3

Examination(s)

Examination Name	Type of Examination	Evaluation	Compulsory / Optional	Weighting
Colloquia, Practical Tasks and Protocols: B.Sc. Laboratory Power Electronics	Other	Not graded	Compulsory	100

Course Content
Experiments: 1. Measuring instruments and measuring methods in power electronics 2. DC chopper 3. Switching power supplies 4. Pulse inverter (power section) 5. Pulse inverter (drive) 6. Simulation and modeling in power electronics 7. Microprocessor controls in power electronics 8. Devices in power electronics
Learning Outcome
The students know power electronic components and can explain the control of power electronic modules. They have knowledge regarding the implementation of the control strategies with microcontrollers in hardware. The students are able to implement and validate the learned control strategies in laboratory experiments.
Reading List
Literature list is handed out in the course.

Use	**Compulsory / Optional**	**Semester**
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2022)	Optional	6.
Bachelor, 1-Subject, Electrical Engineering and Business Management, (Version 2022)	Optional	6.

↑

Module Name	Module Code
B.Sc. Laboratory Micro-Nano-Optosystems	etit4007-01a
Module Coordinator	
Prof. Dr. Martina Gerken Prof. Dr. Hermann Kohlstedt	
Organizer	
Department of Electrical and Information Engineering - Integrated Systems and Photonics	
Department of Electrical and Information Engineering - Nano Electronics	
Faculty	
Faculty of Engineering	
Examination Office	
Examination Office for Electrical Engineering and Information Technology	

ECTS Credits	4
Evaluation	Not graded
Duration	One semester
Frequency	Only takes place during summer semesters
Workload per ECTS Credit	30 hours
Total Workload	120 hours
Contact Time	60 hours
Independent Study	60 hours
Teaching Language	German

Entry Requirements as Stated in the Examination Regulations
• Fundamentals of Electrical Engineering I (Module etit1001-01a)
Recommended Requirements
• Physic for Students of Electrical and Information Engineering (Module MNF-phys-Ing)

Module Courses

Course Type	Course Name	Compul-sory/Optional	SWS
Practical exercise	B.Sc. Laboratory Micro-Nano-Optosystems	Compulsory	4

Examination(s)

Examination Name	Type of Examination	Evaluation	Compulsory / Optional	Weighting
Practical Tasks and Paper: B.Sc. Laboratory Micro-Nano-Optosystems	Other	Not graded	Compulsory	100

Course Content

Experiments:
- Statistical principles of manufacturing technology
- Micromechanical mass flow sensor
- Basics of micromechanical inertial sensors
- Transistor amplifier circuit with feedback
- Operational amplifier
- Magnetic tunnel junctions as non-volatile information storage devices
- Switching mechanisms in ferroelectric capacitors
- SPICE simulations for gates and memories
- Michelson interferometer
- Spectroscopy
- Lasers
- Display technology

Learning Outcome

Students know how micro-, nano- and optotechnological systems work and can describe them using experimental setups. They are able to acquire teaching material independently and familiarize themselves with the topics of the individual experiments. They can independently implement practical tasks in the laboratory, while a supervisor is available for queries. They are able to critically evaluate results. The students are able to present and analyze experimental results independently in writing. They are able to successfully complete tasks in teams.

Reading List

Literature is given in the experimental instructions.

Furthermore:
- F. Pedrotti, L. Pedrotti, W. Bausch, H. Schmidt: Optik für Ingenieure – Grundlagen.
- G. Schröder, H. Treiber: Technische Optik – Grundlagen und Anwendungen.
- E. Hering, R. Martin, M. Stohrer: Physik für Ingenieure.

Chair of Nano Electronics
- Harald Hartl et al., Elektronische Schaltungstechnik Pearson-Studium, ISBN: 978-3-8273-7321-2
- Ultra-Low Voltage Nano-Scale Memories, K. Itoh, M. Horiguchi, H. Tanaka, Springer 2007
- CMOS Processors and Memories, K. Iniewski, Springer 2010
- Nanometer sized CMOS IC`s: From Baiscs to ASICS, H. Veendick, Springer 2008
- Nanotechnology Vol. 3 and 4, Informationtechnology I and II, Wiley-VCH 2008, ed. R.Waser
- Nanoelectronics and Informationtechnology, Adv. Elec. Mat. nnd Novel Dev. Wiley-VCH 2003, ed. R. Waser

Use	Compulsory / Optional	Semester
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2022)	Optional	6.
Bachelor, 1-Subject, Electrical Engineering and Business Management, (Version 2022)	Optional	6.

↑

Module Name	Module Code
B.Sc. Laboratory Communications and Information Technology	etit4008-01a
Module Coordinator	
Prof. Dr.-Ing. Stephan Pachnicke	
Organizer	
Department of Electrical and Information Engineering - Communications	
Faculty	
Faculty of Engineering	
Examination Office	
Examination Office for Electrical Engineering and Information Technology	

ECTS Credits	4
Evaluation	Not graded
Duration	One semester
Frequency	Only takes place during summer semesters
Workload per ECTS Credit	30 hours
Total Workload	120 hours
Contact Time	45 hours
Independent Study	75 hours
Teaching Language	German

Entry Requirements as Stated in the Examination Regulations
• Fundamentals of Electrical Engineering I (Module etit1001-01a)
Recommended Requirements
• Communications (Module etit1009-01a)

Module Courses

Course Type	Course Name	Compul-sory/Optional	SWS
Practical exercise	B.Sc. Laboratory Communications and Information Technology	Compulsory	3

Examination(s)

Examination Name	Type of Examination	Evaluation	Compulsory / Optional	Weighting
Colloquia and Practical Tasks: B.Sc. Laboratory Communications and Information Technology	Other	Not graded	Compulsory	100

Course Content
Experiment No. 1: Amplitude and frequency modulation (AM/FM) Experiment No. 2: Digital modulation Experiment No. 3: Numerical simulation of the AWGN channel Experiment No. 4: Higher-level, complex-valued modulation Experiment No. 5: Line coding Experiment No. 6: Optical measurement techniques Experiment No. 7: Simulation of optical WDM transmission Experiment No. 8: WDM transmission over polymer fiber
Learning Outcome
The students are able to acquire teaching material independently and to familiarize themselves with the topics of the individual experiments. The students are familiar with the measuring instruments used in communications engineering and can operate them. They can independently implement practical tasks in the laboratory under supervision. The students are able to work successfully on tasks in teams.
Reading List
• Kammeyer, K.-D., Dekorsy, A.: Nachrichtenübertragung; 6. Auflage, Springer Vieweg, Wiesbaden, 2018. • Barry, J. R., Lee, E. A., Messerschmitt, D. G.: Digital Communication; 3rd edition, Springer, New York, 2004.

Use	**Compulsory / Optional**	**Semester**
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2022)	Optional	6.
Bachelor, 1-Subject, Electrical Engineering and Business Management, (Version 2022)	Optional	6.

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Module Name	Module Code
B.Sc. Laboratory Control and System Dynamics	etit4009-01a
Module Coordinator	
Priv.-Doz. Dr. Alexander Schaum	
Organizer	
Department of Electrical and Information Engineering - Automatic Control	
Faculty	
Faculty of Engineering	
Examination Office	
Examination Office for Electrical Engineering and Information Technology	

ECTS Credits	4
Evaluation	Not graded
Duration	One semster
Frequency	Only takes place during summer semesters
Workload per ECTS Credit	30 hours
Total Workload	120 hours
Contact Time	60 hours
Independent Study	60 hours
Teaching Language	German

Entry Requirements as Stated in the Examination Regulations

- Fundamentals of Electrical Engineering I (Module etit1001-01a)

Recommended Requirements

- Automatic Control (Module etit1011-01a)

Module Courses

Course Type	Course Name	Compul-sory/Optional	SWS
Practical exercise	B.Sc. Laboratory Control and System Dynamics	Compulsory	4

Examination(s)

Examination Name	Type of Examination	Evaluation	Compulsory / Optional	Weighting
Colloquia, Practical Tasks and Protocols: B.Sc. Laboratory Control and System Dynamics	Other	Not graded	Compulsory	100

Course Content
Experiments on the topics: • Mathematical modeling and system analysis with computer algebra systems • System analysis and numerical simulation with MATLAB/Simulink • Computer-assisted control design for linear systems • Implementation and experimental evaluation
Learning Outcome
The students know the operation and design procedures of linear controllers and observers in the frequency domain and in the state space. They are able to independently derive mathematical models for certain technical processes and to implement and execute them in appropriate symbolic and numerical computer tools (Maxima, MATLAB/Simulink) and to critically evaluate the results. They can develop computer-based control approaches in the frequency domain and in the state space as well as model-based observers and evaluate and assess them in simulations. They know the fundamentals of real-time data processing. The students are familiar with scientific work including literature research, project planning, data analysis, interpretation of results and the written and oral presentation of results according to the scientific standard.
Reading List
• T. Meurer: Regelungstechnik – Skriptum zur Vorlesung.

Use	**Compulsory / Optional**	**Semester**
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2022)	Optional	6.
Bachelor, 1-Subject, Electrical Engineering and Business Management, (Version 2022)	Optional	6.

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Module Name	Module Code
B.Sc. Laboratory Simulation of Optical Sensors	etit4010-01a
Module Coordinator	
Prof. Dr. Martina Gerken	
Organizer	
Department of Electrical and Information Engineering - Integrated Systems and Photonics	
Faculty	
Faculty of Engineering	
Examination Office	
Examination Office for Electrical Engineering and Information Technology	

ECTS Credits	4
Evaluation	Not graded
Duration	One semester
Frequency	Only takes place during summer semesters
Workload per ECTS Credit	30 hours
Total Workload	120 hours
Contact Time	60 hours
Independent Study	60 hours
Teaching Language	German

Entry Requirements as Stated in the Examination Regulations
• Fundamentals of Electrical Engineering I (Module etit1001-01a)
Recommended Requirements
• Mathematics for Engineering Sciences I – III (Modules mathMIng1-01a, mathMIng2-01a and mathMIng3-01a)

Module Courses

Course Type	Course Name	Compulsory/Optional	SWS
Practical exercise	B.Sc. Laboratory Simulation of Optical Sensors	Compulsory	4

Examination(s)

Examination Name	Type of Examination	Evaluation	Compulsory / Optional	Weighting
Colloquia, Practical Tasks, Protocols and Presentation: B.Sc. Laboratory Simulation of Optical Sensors	Other	Not graded	Compulsory	100

Course Content
The B.Sc. Laboratory Simulation of Optical Sensors is a research-based laboratory course designed to give students the opportunity to gain insight into current research on optical sensors, such as ring, plasmon, and waveguide resonators, while formulating their own research question, planning research, and carrying it out in simulation. The laboratory course is divided into the following three phases: Phase 1: Acquisition of knowledge and definition of a research question. • Optical sensor technology • Simulations with the finite element method (FEM) • Matlab evaluation • The research cycle Phase 2: Research based on computer simulations • Project work in groups of 2 • Weekly interim meetings Phase 3: Evaluation, interpretation, presentation of results
Learning Outcome
The students know how optical sensors work and can describe them using models. They are able to design components with the aid of numerical simulation using common finite-element-method (FEM) software. They are able to implement and run simulations independently under supervision and critically evaluate the results. The students are familiar with scientific work using the scientific cycle and are able to implement it. This includes literature research, formulation of a research question, project planning, data analysis, result interpretation as well as the written and oral presentation of the results according to the scientific standard.
Reading List
The literature list is handed out in the course.

Use	Compulsory / Optional	Semester
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2022)	Optional	6.
Bachelor, 1-Subject, Electrical Engineering and Business Management, (Version 2022)	Optional	6.

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Module Name	Module Code
B.Sc. Laboratory System Theory	etit4011-01a
Module Coordinator	
Prof. Dr.-Ing. Gerhard Schmidt	
Organizer	
Department of Electrical and Information Engineering - Digital Signal Processing and System Theory	
Faculty	
Faculty of Engineering	
Examination Office	
Examination Office for Electrical Engineering and Information Technology	

ECTS Credits	4
Evaluation	Not graded
Duration	One semester
Frequency	Only takes place during winter semesters
Workload per ECTS Credit	30 hours
Total Workload	120 hours
Contact Time	45 hours
Independent Study	75 hours
Teaching Language	German

Entry Requirements as Stated in the Examination Regulations

- Fundamentals of Electrical Engineering I (Module etit1001-01a)

Recommended Requirements

- Signals und Systems I (Module etit1005-01a)
- Signals und Systems II (Module etit1008-01a)

Module Courses

Course Type	Course Name	Compul-sory/Optional	SWS
Practical exercise	B.Sc. Laboratory System Theory	Compulsory	3

Examination(s)

Examination Name	Type of Examination	Evaluation	Compulsory / Optional	Weighting
Colloquia and Practical Tasks: B.Sc. Laboratory System Theory	Other	Not graded	Compulsory	100

Course Content
1. Preliminary discussion, handing out of material, clarification of the procedure and preparations. 2. Introduction MATLAB 3. Continuous-time periodic and non-periodic signals: cont. Fourier transform and Fourier series, spectra of selected signals, band-limited jumps, Gibbs phenomenon. 4. Discrete-time periodic and non-periodic signals: spectra of discrete-time signals, signal sampling and signal reconstruction, sampling theorem 5. Discrete Fourier Transform (DFT): time and band-limited signals, not time and band-limited signals, aliasing, DFT and periodic signals, leakage effect, windowing 6. Linear, shift-invariant systems: pole-zero diagrams, frequency responses, time response, linear-phase, minimum-phase and all-pass systems 7. Discrete-time simulation of continuous-time systems: Excitation invariant transform, bilinear transform, spectral overlaps, responses to broadband and narrowband signals. 8. Stochastic signals: distribution and distribution density function, stationary and ergodic stochastic processes, autocorrelation function and power density spectrum 9. Response of linear systems to stochastic signals: system influence on linear mean, variance, autocorrelation, and power density spectrum, influence of linear systems on distribution density of stochastic processes, system identification with random sequences 10. State space representation of systems: Canonical structures, signal flow graphs, controllability and observability.
Learning Outcome
Students are able to work independently on course material and familiarize themselves with the topics of the individual experiments. They can use MATLAB as a tool for working with signals, spectra and systems. They can implement practical tasks in the laboratory independently under supervision. The students are able to successfully work on tasks in teams.
Reading List
The literature list is handed out in the course.

Use	Compulsory / Optional	Semester
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2022)	Optional	5.
Bachelor, 1-Subject, Electrical Engineering and Business Management, (Version 2022)	Optional	5.

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Module Name	Module Code
M.Sc. Laboratory Examples in Computerized IC Testing	etit8008-01a
Module Coordinator	
Prof. Dr. Robert Rieger	
Organizer	
Department of Electrical and Information Engineering - Networked Electronic Systems	
Faculty	
Faculty of Engineering	
Examination Office	
Examination Office for Electrical Engineering and Information Technology	

ECTS Credits	5
Evaluation	Not graded
Duration	One semester
Frequency	Only takes place during summer semesters
Workload per ECTS Credit	30 hours
Total Workload	150 hours
Contact Time	45 hours
Independent Study	105 hours
Teaching Language	English

Module Courses			
Course Type	**Course Name**	**Compul-sory/Optional**	**SWS**
Practical exercise	M.Sc. Laboratory Examples in Computerized IC Testing	Compulsory	2
Seminar	M.Sc. Laboratory Examples in Computerized IC Testing	Compulsory	1

Examination(s)				
Examination Name	**Type of Examination**	**Evaluation**	**Compulsory / Optional**	**Weighting**
Report or Oral Examination: M.Sc. Laboratory Examples in Computerized IC Testing	Other	Not graded	Compulsory	100

Course Content

Gaining practical experience in the measurement and evaluation of integrated circuits is the focus of this module. It is intended to generate understanding for improved design planning with regard to the testability of integrated circuits. Various commercially relevant approaches to computer-based testing will be presented and experienced in practice. In particular, the hardware/software combination of National Instruments Labview+DAQ is used for signal generation and acquisition, Microchip microcontrollers are programmed for test signal generation, digital pattern generation and signal recording, and PCB layouts are created with Diptrace or Eagle design software. PC-based oscilloscopes from Picoscope Inc. are used for mixed-signal monitoring. Examples of practical group work packages are as follow:

- Labview signal generation+measurement - analog: OPA transfer function
- Labview Signal generation+measurement - digital: Counter Frequency measurement
- Microcontroller: ADC+DAC, temperature measurement, SPI interface
- PCB design + manufacturing

Learning Outcome

The students will be familiar with the standard testing solutions provided by NI Labview DAQ, Picoscope, and MPLab and have the essential application skills. They gain experience with practical bench test setup and computer supported testing of electronics hardware so that they are able to apply their knowledge independently on other testing tasks. The students have the ability to read and interpret datasheets and instruction manuals and apply the information independently.

Reading List

- Lab instruction materials (handouts)
- User manuals for Labview, MPLab IDE, Picoscope
- Datasheet for Microchip microcontroller

Use	Compulsory / Optional	Semester
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2022)	Optional	1.
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2017)	Optional	1.
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2016)	Optional	1.
Bachelor, 1-Subject, Electrical and Information Engineering, (Version 2015)	Optional	1.
Bachelor, 1-Subject, Electrical Engineering and Business Management, (Version 2022)	Optional	1.
Bachelor, 1-Subject, Electrical Engineering and Business Management, (Version 2017)	Optional	1.
Bachelor, 1-Subject, Electrical Engineering and Business Management, (Version 2016)	Optional	1.
Bachelor, 1-Subject, Electrical Engineering and Business Management, (Version 2015)	Optional	1.
Master, 1-Subject, Electrical and Information Engineering, (Version 2022)	Optional	1.
Master, 1-Subject, Electrical and Information Engineering, Specialisation Devices and Circuits, (Version 2022)	Optional	1.
Master, 1-Subject, Electrical Engineering and Information Technology, (Version 2019)	Optional	1.
Master, 1-Subject, Electrical Engineering and Information Technology, Specialisation Devices and Circuits, (Version 2019)	Optional	1.
Master, 1-Subject, Electrical and Information Engineering, (Version 2015)	Optional	1.
Master, 1-Subject, Electrical Engineering and Business Management, (Version 2022)	Optional	1.
Master, 1-Subject, Electrical Engineering and Business Management, (Version 2019)	Optional	1.
Master, 1-Subject, Electrical Engineering and Business Management, (Version 2017)	Optional	1.

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