Kiel University
Christian-Albrechts-Universität zu Kiel

Faculty of Engineering

Module Catalogue

for Electrical Engineering and Information Technology

Master, 1-Subject

Version 2019

Table of Contents

Prologue

Information about the contact time

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

Information about the specification in the field "Type of Examination"

For modules for which " Other" is entered in the field "Type of Examination", you find the information on the examination type in the field "Examination Name".

Information on module selection

Modules from other institutes and faculties that are not included in this module handbook of the Master's program Electrical and Information Engineering may be taken after approval by the chairperson of the examination board and with the consent of the offering institution. A recommendation of appropriate modules will be included here in the prologue.

Name	Code
Electrical Engineering and Information Technology (EE&IT)	85|180|-|H|2019|1200
Organizer	
Faculty	
Faculty of Engineering	
Examination Office	

ECTS Credits	90
Evaluation	Graded

Use	Compulsory / Optional	Semester
Master, 1-Subject, Electrical Engineering and Information Technology, (Version 2019)	Compulsory	.

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Name	Code
Core Modules	etit
Organizer	
Faculty	
Faculty of Engineering	
Examination Office	

Evaluation	Graded

Use	Compulsory / Optional	Semester
Master, 1-Subject, Electrical Engineering and Information Technology, (Version 2019)	Compulsory	.

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Module Name	Module Code
Advanced Digital Signal Processing	etit5001-01a
Module Coordinator	
Prof. Dr.-Ing. Gerhard Schmidt	
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	Graded
Duration	One Semester
Frequency	Only takes place during winter semesters
Workload per ECTS Credit	30 hours
Total Workload	150 hours
Contact Time	60
Independent Study	90
Teaching Language	English

Module Courses			
Course Type	**Course Name**	**Compul-sory/Optional**	**SWS**
Lecture	Advanced Digital Signal Processing	Compulsory	3
Exercise	Advanced Digital Signal Processing	Compulsory	1
Prerequisits for Admission to the Examination(s)			
Prerequisites for the examination as stated in the Examination Regulations: Presentation			

Examination(s)				
Examination Name	**Type of Examination**	**Evaluation**	**Compulsory / Optional**	**Weighting**
Oral Examination: Advanced Digital Signal Processing	Oral Examination	Graded	Compulsory	100

Course Content

Digital processing of continuous-time signals
- Sampling and sampling theorem
- Quantization
- AD- and DA-conversion

Efficient FIR structures
- Block-based approaches

DFT and FFT
- Leakage effect
- Windowing
- FFT structure

Digital filters
- FIR filters
- Structures
- Linear phase filters
- Least-squares frequency domain design
- IIR-filters
- Structures
- Finite word-length effects

Multirate digital signal processing
- Decimation and interpolation
- Filters in sampling rate alteration systems
- Polyphase decomposition and efficient structures
- Digital filter banks

Learning Outcome

Students have an in-depth understanding of the differences of analog and digital processing. They apply robust and efficient versions of digital signal processing structures. They compare different filter approaches. Students deepen their knowledge on sampling and complexity reduction.

Reading List

- J.G. Proakis, D.G. Manolakis: Digital Signal Processing: Principles, Algorithms, and Applications, Prentice Hall, 1996, 3rd edition
- S.K. Mitra: Digital Signal Processing: A Computer-Based Approach, McGraw Hill Higher Education, 2000, 2nd edition
- A.V. Oppenheim, R.W. Schafer: Discrete-time signal processing, Prentice Hall, 1999, 2nd edition
- M.H. Hayes Statistical Signal Processing and Modeling, John Wiley and Sons, 1996

Use	Compulsory / Optional	Semester
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, Electric Vehicle Propulsion and Control, (Version 2020)	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
Bio-inspired Information Pathways	etit5020-01a
Module Coordinator	
Prof. Dr. Hermann Kohlstedt	
Organizer	
Department of Electrical and Information Engineering - Nano Electronics	
Department of Electrical and Information Engineering - Theoretical Electrical Engineering	
Department of Electrical and Information Engineering - Bio-inspired Computation	
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	75 hours
Independent Study	75 hours
Teaching Language	English

Module Courses			
Course Type	**Course Name**	**Compul-sory/Optional**	**SWS**
Lecture	Bio-inspired Information Pathways	Compulsory	3
Exercise	Bio-inspired Information Pathways	Compulsory	2

Examination(s)				
Examination Name	**Type of Examination**	**Evaluation**	**Compulsory / Optional**	**Weighting**
Written or Oral Examination: Bio-inspired Information Pathways	Written or Oral Examination	Graded	Compulsory	100

Course Content

- Historical background of brain research
- Information precessing in nervous systems
- Neuron models and network models
- Neuronal circuits
- Memristive materials and devices in neuronal circuits

Learning Outcome

The students canm describe the historical developoment of brain research and explain basal information pathways in nervous systems. They are able to verify and explain basic neuron models. They can explain neuronal mixed-signal circuits. Students are capable of describing the function of memristive devices and related neuromorphic circuits.

Reading List

- In Search of Memory, Eric R. Kandel, W. W. Norton & Company, New York 2006.
- Der Beobachter im Gehirn, Wolf Singer, Suhrkamp Verlag, Frankfurt 2002.
- Bewusst oder Unbewusst?, Heinz Georg Schuster, Wiley-VCH, Weinheim 2007.
- Analog VLSI: Circuits and Principles, ed. by Liu et al., The MIT Press 2002.
- Physics of Semiconductor Devices, S. M. Sze and Kwok K. NG, Wiley-Interscience, 2006.
- Modeling Brain Function, Daniel J. Amit, Cambridge University Press 1989.
- Neural Networks for Signal Processing, Bart Kosko, Prentice Hall Inc., Englewood Cliffs, NJ 07632, 1992
- Resistive Switching: From Fundamentals of Nanoionic Redox Processes to Memristive Device Applications Ielmini, Daniele / Waser, Rainer (Editor), Wiley-VCH, Weinheim (2016)

Use	Compulsory / Optional	Semester
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
Design of Power Electronics Converters	etit5002-01a
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	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	52,5
Independent Study	97,5
Teaching Language	English

Module Courses			
Course Type	**Course Name**	**Compul-sory/Optional**	**SWS**
Lecture	Design of Power Electronics Converters	Compulsory	2
Exercise	Design of Power Electronics Converters	Compulsory	1,5

Examination(s)				
Examination Name	**Type of Examination**	**Evaluation**	**Compulsory / Optional**	**Weighting**
Written or Oral Examination: Design of Power Electronics Converters	Written or Oral Examination	Graded	Compulsory	100

Course Content

The course is a basic course for developing a career in power electronics. The current drivers in power electronics design are efficiency, reliability and cost. Reliability has become only recently one of the main topics in power electronics and it is expected to be a major player in future years, due to the growing use of power electronics and the consequent safety concerns. Furthermore reliability affects deeply the cost of the system because of the cost of maintenance. Both reliability and efficiency depend on the management of the temperature, hence thermal models are very important. The topologies of PWM converters and the modulation have a deep impact on efficiency and reliability as well as on the power quality.

Topics overview:

- Design of a power electronics converter (semiconductors and drivers, soft and hard switching, busbar design, EMC problems and remedies, thermal model)
- Topologies of PWM power converters (dc/dc, dc/ac, ac/ac): single-cell and multi-cell converters, matrix converters etc.
- PWM modulation (single-phase, three-phase, space-vector, multilevel, interleaving, continuous/discontinuous, optimized)

Learning Outcome

The students have an in-depth knowledge in the design process of power electronics converters characterized by high efficiency and high reliability. The students have developed a working understanding about how to handle the electrical energy conversions in applications ranging from power supplies to renewable energies and electric drives. The students focus on power converters based on Pulse Width Modulation, and are able to design the power converter starting from the components (mainly semiconductors, passive elements and cooling system) toward the choice of the proper topology and consequently the selection of the modulation strategy.

Reading List

- N. Mohan, T. M. Undeland e W. P. Robbins, “Power Electronics: Converters, Applications, and Design”, Wiley, 2002, 0471226939.
- D.G. Holmes and T. Lipo, “Pulse Width Modulation for Power Converters : Principles and Practice”, Wiley 2003, ISBN 0471208140.
- B. Bose, “Modern Power Electronics and A.C. Drives”, Prentice Hall, 2001, ISBN 013016743.

Use	Compulsory / Optional	Semester
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, Electric Vehicle Propulsion and Control, (Version 2020)	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
Digital Communications II	etit5003-01a
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 winter semesters
Workload per ECTS Credit	30 hours
Total Workload	150 hours
Contact Time	60
Independent Study	90
Teaching Language	English

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

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

Course Content

Equalization of digital transmission systems: Fundamentals of FIR-equalizers, blind equalization, nonlinear equalization, optimum receivers, maximum likelihood sequence estimation, Viterbi detector.

Code-division multiple access (CDMA): Working principle, pseudo-noise sequence, code synchronization.

Multicarrier transmission (OFDM, DMT): Working principle, digital implementation using DFT, guard interval, equalization, symbol mapping, bit- and power loading, PAPR reduction, spectral properties, system examples.

MIMO-Systems: Development & benefits, system model, eigenmodes, MIMO channel capacity and „water-filling“ principle, successive interference cancellation, diversity, maximum ratio combining, application examples for future MIMO-systems with multi-mode or multi-core fibers.

Introduction into channel coding: Working principle, block codes, convolutional codes, signal space coding, channel capacity and Shannon-limit.

Application examples: Digital Audio Broadcasting (DAB), Digital Video Broadcasting (DVB), Digital Subscriber Line (DSL), WIFI (Wireless LAN), Bluetooth, optical wireless transmission, inter-satellite communications, optical underwater communications, fiber-optical high-speed transmission

Learning Outcome

This module teaches advanced knowledge in digital communications. The students will be able to understand the basic working principles of exemplary transmission systems. They know the major equalization techniques and advanced modulation formats. Based on that they will be enabled to build and assess digital communication systems on their own.

Reading List

- J. R. Barry, E. A. Lee, D. G. Messerschmitt, „Digital Communication“, Springer, 2003 (3rd edition)
- J. G. Proakis, „Digital Communications“, McGraw-Hill, 2008 (5th edition)

Use	Compulsory / Optional	Semester
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.

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Module Name	Module Code
Digital Electronics	etit5004-01a
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
Independent Study	105
Teaching Language	English

Recommended Requirements

- Basics in Electronics
- Materials Science Lecture

Module Courses

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

Examination(s)

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

Course Content

1-Logic circuits
Boolean algebra, logic and logic gates, combinational logic circuits, sequential logic circuits, circuit design (VLSI and ASICs)
2-Limits of Binary Computation
Binary states variables, physical limits of computation, Moore's law
3-Random Access Memories
DRAM, Flash memories (EPROM, EEPROM), FeRAM ,FeFET, MTJ, MRAM
4-Resistive Random Access Memories
The memory gap problem, PCM, FTJ, ECM and VCM, TCM
5-Mass Storage
DVD, Hard Disk Drives

Learning Outcome

Students acquire an overview on current RAM technologies: the physical background, typical applications and physical limits of different RAM and mass storage devices. They have a profound understanding of various RAM technologies and valuation of their advantages and disadvantages. They can describe current difficulties and developments in RAM-technologies and have an overview of recent research approaches. Students are able to design logic circuits and can explain their principle function. They understand the physical background of different RAM devices, their scaling limits and functional principles.

Reading List

- 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
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
Fields and Waves in Biological Systems	etit5005-01a
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	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
Independent Study	105
Teaching Language	English

Module Courses			
Course Type	**Course Name**	**Compul-sory/Optional**	**SWS**
Lecture	Fields and Waves in Biological Systems	Compulsory	2
Exercise	Fields and Waves in Biological System	Compulsory	1

Examination(s)				
Examination Name	**Type of Examination**	**Evaluation**	**Compulsory / Optional**	**Weighting**
Written or Oral Examination: Fields and Waves in Biological Systems	Written or Oral Examination	Graded	Compulsory	100

Course Content

Basic equations:
Maxwell’s equations, curl-free quasistationary fields, diffusion, Nernst-Planck equation
Electrical properties of the cell:
Diffusion und ionic currents in the cell membrane, ion channels, sodium-potassium-pump, Nernst potential, equivalent circuit, Hodgkin-Huxley model
Nerve cells:
Structure and function, cable equation, propagation along an axon
Electrical properties of the heart:
Basic anatomy, electrical system, electrocardiography (ECG), magnetocardiography (MCG), pacemaker
Electrical properties of the brain:
Basic anatomy, Electroencephalography (EEG), magneto encephalography (MEG), deep-brain stimulation (DBS)
The eye as an electromagnetic sensor:
Basic anatomy, light reception in the retina and corresponding network
Biological effects of electromagnetic fields:
Effects of low-frequency electric and magnetic fields Effects of high-frequency electromagnetic fields

Learning Outcome

The students are able to describe the electrophysiological processes in the human body and several electromagnetically based methods for diagnosis and therapy. They are able to judge the electromagnetic effects in and threats to living organism and have the ability to electrically model electrophysiological processes.

Reading List

- J. Keener, J. Sneyd: Mathematical Physiology (Teile 1 und 2), 2nd ed., Springer, 2009.
- J. Malmivuo, R. Plonsey: Bioelectromagnetism, Oxford University Press, 1995.
- R. M. Gulrajani: EMC Bioelectricity and Biomagnetism, Wiley. 1998.
- R. Feynman, R. Leighton, M. Sands: The Feynman Lectures on Physics, Part II, AddisonWesley, 1977.

Use	Compulsory / Optional	Semester
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 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.

Module Name	Module Code
Information Theory and Coding I	etit5007-01a
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 winter semesters
Workload per ECTS Credit	30 hours
Total Workload	150 hours
Contact Time	45
Independent Study	105
Teaching Language	English

Module Courses			
Course Type	**Course Name**	**Compul-sory/Optional**	**SWS**
Lecture	Information Theory and Coding I	Compulsory	2
Exercise	Information Theory and Coding I	Compulsory	1

Examination(s)				
Examination Name	**Type of Examination**	**Evaluation**	**Compulsory / Optional**	**Weighting**
Written Examination: Information Theory and Coding I	Written Examination	Graded	Compulsory	100

Course Content

Fundamentals:
Shannon’s source coding theorem, Shannon’s channel coding theorem, Shannon’s crypto system
Multiuser information theory:
Broadcast channel, multiple-access channel, relay channel, channel capacity for Gaussian multiuser channels
Joint source and channel coding:
Lossy source coding, Shannon’s rate-distortion theory
Network coding

Learning Outcome

The students acquire an in-depth knowledge on information theory. They are able to professionally use source coding methods (data compression), channel coding techniques (error correction and error detection), and cryptology (data security). They gain insight into multiuser communication and network coding. The students are able to assess the performance of modern information systems by means of theoretical bounds and/or computer simulation.

Reading List

- Cover, T.M. and Thomas, J.A.: Elements of Information Theory. John Wiley & Sons, 2nd ed., 2006.
- Yeung, R.W.: A First Course in Information Theory. Springer, 2002.
- Yeung, R.W.: Information Theory and Network Coding. Springer, 2008.

Additional German Reading:

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

Use	Compulsory / Optional	Semester
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.

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Module Name	Module Code
Information Theory and Coding II	etit5008-01a
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
Independent Study	105
Teaching Language	English

Recommended Requirements

- „Information Theory & Coding I” (module etit5007-01a) is NO prerequisite

Module Courses

Course Type	Course Name	Compul-sory/Optional	SWS
Lecture	Information Theory and Coding II	Compulsory	2
Exercise	Information Theory and Coding II	Compulsory	1

Examination(s)

Examination Name	Type of Examination	Evaluation	Compulsory / Optional	Weighting
Written Examination: Information Theory and Coding II	Written Examina-tion	Graded	Compulsory	100

Course Content

Fundamentals of channel coding: Block codes and convolutional codes

Fundamentals of channel decoding: Viterbi algorithm, List Viterbi algorithm, BCJR algorithm, sequential decoding, sphere decoding, belief propagation

LDPC codes: Tanner graph, design principles of LDPC codes, rateless codes

Turbo codes: LLR algebra, BCJR algorithm, EXIT chart analysis, parallel and serial code concatenation

Coded modulation: Trellis-coded modulation, multilevel coding, bit-interleaved coded modulation, superposition modulation

Polar codes: Channel polarization, design principle of polar codes, capacity proof, decoding of polar codes

Learning Outcome

The students acquire an in-depth knowledge about channel coding and corresponding decoding algorithms. They can protect data against transmission/storage errors in applications like wireless radio, optical communications, and CD/DVD/bluRay discs. The students are able to design and to evaluate powerful channel coding techniques, and they can design and evaluate advanced channel decoding algorithms.

Reading List

- Lin, S., Costello, D.J.: Error Control Coding, Prentice-Hall. 2nd ed., 2004.
- Richardson, T., Urbanke, R.: Modern Coding Theory. Cambridge University Press, 2008.
- Ryan, W.E., Lin, S.: Channel Codes: Classical and Modern. Cambridge University Press, 2009.

Additional German Reading:

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

Use	Compulsory / Optional	Semester
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.

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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
Mathematical Methods in Field Theory	etit5009-01a
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	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
Independent Study	105
Teaching Language	English

Module Courses			
Course Type	**Course Name**	**Compul-sory/Optional**	**SWS**
Lecture	Mathematical Methods in Field Theory	Compulsory	2
Exercise	Mathematical Methods in Field Theory	Compulsory	1

Examination(s)				
Examination Name	**Type of Examination**	**Evaluation**	**Compulsory / Optional**	**Weighting**
Oral Examination: Mathematical Methods in Field Theory	Oral Examination	Graded	Compulsory	100

Course Content

Mathematical foundations:
Dirac "#-Function", #-convergent series, ortho-normalized function systems, Sturm-Liouville-Theory (Solution of boundary value problems with ordinary 2nd order differential equations)
Green‘s functions:
Definition, properties, representations, solution of boundary value problems by means of Green’s functions, 1st and 2nd boundary value problems (Dirichlet and Neumann problems)
Helmholtz- and Laplace equation:
Separation in plane-polar coordinates, separation in spherical coordinates, free-space solutions
Multipole analysis of electromagnetic fields:
Maxwell‘s equations, spherical-multipole analysis, plane-wave expansion, Diffraction by a sphere (Mie theory)

Learning Outcome

The students are able to describe standard mathematical methods in field theory and to analytically calculate scalar und vector fields. They can judge general features of linear operator equations in field theory and neighboring disciplines, e.g. systems theory. Students have the ability to mathematically model corresponding problems in engineering.

Reading List

- Sommerfeld, A.: Partial differential equations in Physics. (Lectures on Theoretical Physics, Part VI). Thun: Harri-Deutsch, 1978
- Abramowitz, M.A.; Stegun, I.A.: Handbook of Mathematical Functions. New York: Dover, 1970
- Watson, A Treatise on the Theory of Bessel Functions (reprint of 2nd edition), Cambridge University Press, 1995
- Bowman, J.J.; Senior, T.B.A.; Uslenghi, P.L.E.: Electromagnetic and Acoustic Scattering by Simple Shapes. Amsterdam: North Holland, 1969
- Stratton, J.A.: Electromagnetic Theory. New York: McGraw-Hill, 1941
- Blume, S.; Klinkenbusch, L.: Spherical-Multipole Analysis in Electromagnetics. in: Werner, D.H.; Mittra, R.: Frontiers in Electromagnetics, New York: IEEE Press, 1999

Use	Compulsory / Optional	Semester
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, Electric Vehicle Propulsion and Control, (Version 2020)	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.

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Module Name	Module Code
Microwave Circuits and Systems: Passive Circuits	etit5010-01a
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	60
Independent Study	90
Teaching Language	English

Recommended Requirements

- Knowledge about microwave technology of a B.Sc., general knowledge about circuits

Module Courses

Course Type	Course Name	Compul-sory/Optional	SWS
Lecture	Microwave Circuits and Systems: Passive Circuits	Compulsory	2
Exercise	Microwave Circuits and Systems: Passive Circuits	Compulsory	2

Examination(s)

Examination Name	Type of Examination	Evaluation	Compulsory / Optional	Weighting
Oral Examination: Microwave Circuits and Systems: Passive Circuits	Oral Examination	Graded	Compulsory	100

Course Content

1. Introduction
Overview, Examples and Relevance of Passive Components for Microwave Circuits and System

2. Important Matrix Descriptions for Microwave Network Analysis
Scattering Matrix (eigen-reflections, unitarity condition), Scattering-Transfer-Matrix, Immittance matrices, ABCD-matrix, Signal Flow Graphs

3. Transmission lines for micro- and millimeter-waves
Two-wire line, Coaxial line, Stripline, Microstrip, Coplanar line, Slotline, Finline, Rectangular waveguide.

4. Fundamentals and design procedures for Passive Components consisting of lumped elements and transmission lines
- Symmetry transformers (Baluns),
- Directional couplers (Ideal directional couplers, Quadrature directional couplers, Four-port symmetry, Analysis by eigen-reflections, Proximity coupler, Design for broader bandwidth, 0°-180°-directional couplers, Flux coupled transformer, Rat-race coupler, Magic-T, Wilkinson Power Divider, Resistive couplers),
- Circulators (Eigenmodes, Intrinsic impedance).

Learning Outcome

The students have an in-depth understanding about the structure and function of passive microwave components. They can apply the principles and procedures for the design of passive microwave components. They have the knowledge of the pros and cons of different components. The students can design components regarding given system requirements. They are able to improve microwave components and create new ones. The students have an understanding of complex radiofrequency systems and are able to describe these systems.

Reading List

- D. M. Pozar: “Microwave Engineering.” Willey, 4th ed. 2011
- R. K. Mongia, I. J. Bahl, P. Bhartia, J. Hong: “RF and Microwave Coupled-Line Circuits.” Artech House, 2nd d. 2007
- R. A. Mack, J. Sevick: “Sevick's Transmission Line Transformers: Theory and Practice.” SciTech Publishing, 5th ed., 2014
- I. Bahl: “Lumped Elements for RF and Microwave Circuits.” Artech House, 2003
- L. Maloratsky: “Passive RF & Microwave Integrated Circuits.” Elsevier/Newnes, 2003
- G. H. Owyang: “Foundations for Microwave Circuits.” Springer, 1989
- C.G. Montgomery, R.H. Dicke, E.M. Purcell: “Principles of Microwave Circuits.” McGraw-Hill/IEE, 1948/2007
- J. Helszajn: Passive and Active Microwave Circuits, Wiley & Sons

Additional German Reading
- Zinke, Brunswig: “Hochfrequenztechnik 2”, Springer
- Meinke, Gundlach “Taschenbuch der Hochfrequenztechnik 2/3”, Springer

Use	Compulsory / Optional	Semester
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.

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Module Name	Module Code
Modeling and Control of Power Electronics Converters	etit5011-01a
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	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	52,5
Independent Study	97,5
Teaching Language	English

Module Courses			
Course Type	**Course Name**	**Compul-sory/Optional**	**SWS**
Lecture	Modeling and Control of Power Electronics Converters	Compulsory	2
Exercise	Modeling and Control of Power Electronics Converters	Compulsory	1,5

Examination(s)				
Examination Name	**Type of Examination**	**Evaluation**	**Compulsory / Optional**	**Weighting**
Written Examination: Modeling and Control of Power Electronics Converters	Written Examination	Graded	Compulsory	100

Course Content

The course is focused on dc/dc and dc/ac PWM converters, their model and their control. Particularly, since most of the adopted dc/ac converters in electric drives and renewable energies are voltage source converters, the current control is the first and most important control stage and it is responsible of high dynamical behavior and low harmonic content. Finally the course focuses on how to select current references to achieve the desired active and reactive powers even in unbalance situations, using the instantaneous power theory, nowadays an indispensable tool for smart grid technologies.
Topics overview:

- dc/dc converter model
- Average model, small-signal linearization, transfer functions
- Design of the controller for dc/dc converters
- dc/ac converter model: ac dynamics in different reference frames
- Continuous and discrete current control (PI, resonant controller, deadbeat)
- dc voltage control, active and reactive power controls

Learning Outcome

The students are able to derive the mathematical models of PWM dc/dc and dc/ac converters. The students are able to design their controllers using average model and small-signal linearization. The students know basic of digital control and learn how to apply to power converters. The students have understanding of power theories and their application to power quality conditioner.

Reading List

- N. Mohan, T. M. Undeland e W. P. Robbins, “Power Electronics: Converters, Applications, and Design”, Wiley, 2002, 0471226939.
- M. P. Kazmierkowski, R. Krishnan, F. Blaabjerg, “Control in Power Electronics”, Academic Press, 2002, ISBN 0-12-40277205.
- R. W. Erickson, D. Maksimovic, “Fundamentals of Power Electronics”, Kluwer Academic Publishers, 2001, ISBN 0792372700.
- R. Teodorescu, M. Liserre, P. Rodriguez “Grid Converters for Photovoltaic and Wind Power Systems”, Wiley-IEEE, ISBN 8-0-470-05751-3, January 2011.
- H. Akagi, E. H. Watanabe, M. Aredes “Instantaneous Power Theory and Applications to Power Conditioning” Wiley, ISBN 0470107618, 2007.

Use	Compulsory / Optional	Semester
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, Electric Vehicle Propulsion and Control, (Version 2020)	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
Neuromorphic Engineering	etit5012-01a
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	60
Independent Study	90
Teaching Language	English

Recommended Requirements

- Electroncis (module etit-105)
- Material Science Lecture (module mawi-E007)
- Mathematics I-III (modules MIng-1, MIng-2 and MIng-3)

Module Courses

Course Type	Course Name	Compul-sory/Optional	SWS
Lecture	Neuromorphic Engineering	Compulsory	2
Exercise	Neuromorphic Engineering	Compulsory	2

Examination(s)

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

Course Content

- Biophysical information pathways
- Short and long-term potentiation, plasticity
- Hebbian learning rule
- Neuronal analog circuits: Axon Hillock circuit, LIF-Neuron, Spike
- Memristors
- Neuron Models: single and two-dimensional neuron models; spiking neuron models
- Oscillations and synchrony
- Models of Synaptic Plasticity: Hebbian models; Learning equations; Plasticity and coding
- Neural Networks:
- Memory and Attractor Dynamics; Topologies; Population Models
- Perceptron, Adalein/Madaline, Advanced Network Structures

Learning Outcome

The course provides a thorough understanding of the basics of biological information processing, as well as the related computational and theoretical neuroscience.

Knowledge: the most important concepts and methods of computational neuroscience

Understanding of:
Functioning of neurons in the nervous system, comparison between digital Computers and bio-inspired computing, basics of learning in biological systems, analog circuits for neuro-informatics, Hebbian learn rule, basics of: Perceptron, Adaline and Madaline, feed forward structure, backpropagation, Hopfield Modell, WTA, Memristors

Skills:
Description of fundamental biophysical mechanism in nerve cells, Advantages and disadvantage of neural networks, Explanation of various analog circuits for neural applications, description of the Memristor principle including the material background mathematical interpenetration of neural networks; design of neural networks and computation principles in bio-inspired systems; non-linear systems; concepts for the implementation of cognition and decision making. Competencies: Ability to understand and develop neural networks. Understanding of bio-inspired computation scheme and their implementation in circuit models.

Reading List

- Neuronal Dynamics: From single neurons to networks and models of cognition, Wulfram Gerstner, Werner M. Kistler, Richard Naud and Liam Paninski, Cambridge University Press.
- Analog VLSI and Neural Systems, C. Mead, Addison-Wesley Pub. Comp. 1989
- In Search of Memory, Eric R. Kandel, W. W. Norton & Company, New York 2006
- Der Beobachter im Gehirn, Wolf Singer, Suhrkamp Verlag, Frankfurt 2002
- Principles of Neural Science, E. Kandel et al. Elsevier, 2008

Use	Compulsory / Optional	Semester
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
Nonlinear Control Systems	etit5013-01a
Module Coordinator	
Prof. Dr.-Ing. habil. Thomas Meurer	
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	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
Independent Study	90
Teaching Language	English

Module Courses			
Course Type	**Course Name**	**Compul-sory/Optional**	**SWS**
Lecture	Nonlinear Control Systems	Compulsory	3
Exercise	Nonlinear Control Systems	Compulsory	1

Examination(s)				
Examination Name	**Type of Examination**	**Evaluation**	**Compulsory / Optional**	**Weighting**
Oral Examination: Nonlinear Control Systems	Oral Examination	Graded	Compulsory	100

Course Content

- Introduction to the dynamic analysis of nonlinear systems
- Lyapunov theory and Lyapunov-based design methods
- Differential geometric basics and methods
- Exact input-output linearization and exact input-state linearization
- Differential flatness
- Computer-algebra-systems in control design

Learning Outcome

The students have an in-depth understanding of nonlinear control systems. They understand the underlying differential geometric concepts and are able to apply these to new problems. The students are able to analyze control theoretic properties. They have a comprehensive understanding of the nonlinear control design methods and are able to independently apply these methods to nonlinear control problems.

Reading List

- T. Meurer: Nonlinear Control Systems, Lecture notes.
- H. Nijmeijer, A.J. van der Schaft: Nonlinear Dynamical Control Systems. Springer, New York.
- A. Isidori: Nonlinear Control Systems. Springer-Verlag, Berlin.
- H.K. Khalil: Nonlinear Systems, Prentice Hall, New Jersey.
- M. Krstic, I. Kanellakopoulos, P. Kokotovc: Nonlinear and Adaptive Control Design, John Wiley & Sons, New York.
- S. Sastry: Nonlinear Systems. Springer-Verlag, New York.
- E. Slotine, W. Li: Applied Nonlinear Control, Prentice Hall, New Jersey.
- M. Vidyasagar: Nonlinear Systems Analysis, Prentice Hall, New Jersey.

Use	Compulsory / Optional	Semester
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, Electric Vehicle Propulsion and Control, (Version 2020)	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.

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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
Optimization and Optimal Control	etit5015-01a
Module Coordinator	
Prof. Dr.-Ing. habil. Thomas Meurer	
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	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	60
Independent Study	90
Teaching Language	English

Recommended Requirements

- Nonlinear Control Systems (Module etit5013-01a)

Module Courses

Course Type	Course Name	Compul-sory/Optional	SWS
Lecture	Optimization and Optimal Control	Compulsory	3
Exercise	Optimization and Optimal Control	Compulsory	1

Examination(s)

Examination Name	Type of Examination	Evaluation	Compulsory / Optional	Weighting
Oral Examination: Optimization and Optimal Control	Oral Examination	Graded	Compulsory	100

Course Content

- Fundamentals of static and dynamic optimization problems
- Static optimization without and with constraints
- Dynamic optimization without and with constraints
- Introduction to numerical methods for optimization.

Learning Outcome

The students have an in-depth understanding of static and dynamics optimization with constraints. They understand the underlying mathematical concepts and are able to apply these to new problems. They have a comprehensive understanding of optimization methods and are able to independently apply these methods to static and dynamic optimization problems. The students know different numerical solution approaches, comprehend their working principles and are able to implement them for optimization problems.

Reading List

- T. Meurer: Optimization and Optimal Control, Lecture notes.
- S. Boyd, L. Vandenberghe: Convex Optimization, Cambridge University Press.
- A.E. Bryson: Dynamic Optimization, Addison-Wesley.
- D.G. Luenberger, Y. Ye: Linear and Nonlinear Programming, Springer.
- J. Nocedal, S.J. Wright: Numerical Optimization, Springer.

Use	Compulsory / Optional	Semester
Bachelor, 1-Subject, Business Economics, (Version 2014)	Optional	1.
Bachelor, 1-Subject, Economics, (Version 2014)	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, Electric Vehicle Propulsion and Control, (Version 2020)	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.

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Module Name	Module Code
Rigid Body Dynamics and Robotics	etit5018-01a
Module Coordinator	
Prof. Dr.-Ing. habil. Thomas Meurer	
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	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
Independent Study	105
Teaching Language	English

Module Courses			
Course Type	**Course Name**	**Compul-sory/Optional**	**SWS**
Lecture	Rigid Body Dynamics and Robotics	Compulsory	2
Exercise	Rigid Body Dynamics and Robotics	Compulsory	1

Examination(s)				
Examination Name	**Type of Examination**	**Evaluation**	**Compulsory / Optional**	**Weighting**
Written Examination: Rigid Body Dynamics and Robotics	Written Examination	Graded	Compulsory	100

Course Content

- Rigid body kinematics
- Rigid body dynamics
- Analytical mechanics
- Robot kinematics, inverse kinematics and dynamics

Learning Outcome

The students have an in-depth understanding of rigid body kinematics and dynamics. They understand the underlying mathematical concepts and are able to apply these to new problems. They have a comprehensive understanding of the principles of analytical mechanics. The students can apply this knowledge to mathematically describe and analyze the kinematic and the kinetics of multi-body and robot systems. They comprehend the basic principles for model-based control of robot systems and are able to apply these.

Reading List

- T. Meurer: Mathematical Modeling, Lecture notes.
- M. W. Spong, M. Vidyasagar, Robot Dynamics and Control, John Wiley & Sons, New York.
- L. Meirovitch: Principles and Techniques of Vibrations, Prentice Hall.
- J.N. Reddy: Energy Principles and Variational Methods in Applied Mechanics, John Wiley & Sons, New York.
- B. Siciliano, L. Sciavicco, L. Villani und G. Oriolo. Robotics: Modelling, Planning and Control, Springer-Verlag, London.

Use	Compulsory / Optional	Semester
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, Electric Vehicle Propulsion and Control, (Version 2020)	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.

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Module Name	Module Code
Semiconductor Technology	etit5019-01a
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	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
Independent Study	105
Teaching Language	English

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

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

Course Content
This lecture introduces the basics of semiconductor technology. Major aspects are silicon wafer technology, doping of silicon (diffusion, implantation), oxides in semiconductor technology, lithography techniques (UV as well as modern approaches), thin film deposition (PECVD, sputtering, evaporation, pulse laser deposition) and etching methods (dry and wet). The central aspect of the process integration of the individual technology steps is first discussed within the framework of the complementary metal oxide semiconductor process (CMOS), but partly also for micro-electromechanical systems (MEMS).

Learning Outcome

Students can explain the basic technologies and processes of semiconductor technology and discuss them in the context of CMOS technology. They can evaluate the different technologies against each other and name the main advantages and limitations. Simple process sequences can be evaluated independently. The students have the basics for advanced courses in the field of Nanoelectronics as well as Micro- and Nanosystem technology.

Reading List

1. J. Plummer et al., Silicon VLSI Technology, Prentice
2. M. Madou, Fundamentals of microfabrication: the science of miniaturization, CRC Press
3. K. Seeger, Semiconductor Physics, Springer
4. C. Kittel, Introduction to Solid State Physics, Wiley

Additional German Reading
1. U. Hilleringmann, Silizium-Halbleitertechnologie, Teubner

Use	Compulsory / Optional	Semester
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
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
In-depth Modules	etit
Organizer	
Faculty	
Faculty of Engineering	
Examination Office	

Evaluation	Graded

Use	Compulsory / Optional	Semester
Master, 1-Subject, Electrical Engineering and Information Technology, (Version 2019)	Compulsory	.

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Module Name	Module Code
Adaptive Filters	etit6003-01a
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
Independent Study	90
Teaching Language	English

Module Courses			
Course Type	**Course Name**	**Compul-sory/Optional**	**SWS**
Lecture	Adaptive Filters	Compulsory	3
Exercise	Adaptive Filters	Compulsory	1
Prerequisits for Admission to the Examination(s)			
Prerequisites for the examination as stated in the Examination Regulations: Presentation			

Examination(s)				
Examination Name	**Type of Examination**	**Evaluation**	**Compulsory / Optional**	**Weighting**
Oral Examination: Adaptive Filters	Oral Examination	Graded	Compulsory	100

Course Content

Students attending this lecture should learn the basics of adaptive filters. To achieve this, necessary algorithms will be derived and applied to problems arising in speech and audio processing. The algorithms comprise Wiener filtering, linear prediction, and adaptive schemes such as the NLMS algorithm, affine projection, and the RLS algorithm. For applications from speech and audio processing we use noise and reverberation reduction, echo cancellation, and beamforming.

Topic overview:

- Introduction and application examples (part 1 of 2)
- Signal properties and cost functions
- Wiener filter and principle of orthogonality
- Linear prediction
- RLS algorithm
- LMS algorithm and its normalized version
- Affine projection algorithm
- Fast version of adaptive algorithms
- Control of adaptive filters
- Efficient processing structures
- Applications of linear prediction
- Outlook and application examples (part 2 of 2)

Learning Outcome

Students can understand gradient-based learning rules which differ in terms of convergence speed and numerical complexity. Students comparing different approaches in a variety of signal and system properties. They apply the learned approaches to real-world problems. Furthermore, they can do research on related topics and present the results in a single person fashion or as a group work.

Reading List

- E. Hänsler, G. Schmidt: Acoustic Echo and Noise Control, Wiley, 2004
- S. Haykin: Adaptive Filter Theory, Prentice Hall, 2002
- A. Sayed: Fundamentals of Adaptive Filtering, Wiley, 2004

Use	Compulsory / Optional	Semester
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.

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Module Name	Module Code
Advanced Engineering Mathematics	mathMIng4e-01a
Module Coordinator	
Prof. Dr. Detlef Müller	
Organizer	
Faculty	
Faculty of Mathematics and Natural Sciences	
Examination Office	

ECTS Credits	5
Evaluation	Graded
Duration	ein Semester
Frequency	Only takes place during summer semesters
Workload per ECTS Credit	30 hours
Total Workload	150 hours
Contact Time	42 hours
Independent Study	108 hours
Teaching Language	English

Entry Requirements as Stated in the Examination Regulations
Prerequisits may be appointed as per §4a Fachprüfungsordnung Mathematik (examination regulations) of 2017. Details will be announced at the start of the courses. It is strongly recommended to attend the lectures and tutorials.
Recommended Requirements
Mathematical foundations as typically taught in a Bachelor study course in Engineering. See for example the German modules Mathematik für die Ingenieurwissenschaften I, Mathematik für die Ingenieurwissenschaften II, Mathematik für die Ingenieurwissenschaften III.

Examination(s)				
Examination Name	**Type of Examination**	**Evaluation**	**Compulsory / Optional**	**Weighting**
Written or Oral Examination: Advanced Engineering Mathematics	Written or Oral Examination	Graded	Compulsory	-
Further Information on the Examination(s)				
Written exam (max. 180 minutes) or oral exam (max. 30 minutes), graded, weight 100%				

Course Content
Typically, the main topic is Complex Analysis, that is: • Complex functions: continuity, differentiability, holomorphic functions, Cauchy-Riemann differential equations, harmonic functions, conformal maps • Complex line integrals, Cauchy Integral Theorem, Cauchy Integral Formula • Power series of holomorphic function, radius of convergence, Identity Theorem • Complex logarithm, ambiguity, Riemann surface • Laurent series, isolated singularities, residual and Residual Theorem, application to improper real integrals • Possible additions: maximum principle, Schwarz Lemma, Liouville's Theorem, Rouché's Theorem
Learning Outcome
Students are familiar with the foundations of complex analysis and its applications, e. g., to real integrals.
Reading List
Additional Information
Contact time is based on a semester of 14 weeks.

Use	Compulsory / Optional	Semester
Master, 1-Subject, Electrical and Information Engineering, (Version 2022)	Optional	2.
Master, 1-Subject, Electrical and Information Engineering, Specialisation Automation and Control, (Version 2022)	Optional	2.
Master, 1-Subject, Electrical and Information Engineering, Specialisation Devices and Circuits, (Version 2022)	Optional	2.
Master, 1-Subject, Electrical and Information Engineering, Specialisation Digital Communications, (Version 2022)	Optional	2.
Master, 1-Subject, Electrical and Information Engineering, Specialisation Medical Applications, (Version 2022)	Optional	2.
Master, 1-Subject, Electrical and Information Engineering, Specialisation Power Electronics, Control and Communications in Energy Systems, (Version 2022)	Optional	2.
Master, 1-Subject, Electrical Engineering and Information Technology, (Version 2019)	Optional	2.
Master, 1-Subject, Electrical Engineering and Information Technology, Specialisation Automation and Control, (Version 2019)	Optional	2.
Master, 1-Subject, Electrical Engineering and Information Technology, Specialisation Devices and Circuits, (Version 2019)	Optional	2.
Master, 1-Subject, Electrical Engineering and Information Technology, Specialisation Digital Communications, (Version 2019)	Optional	2.
Master, 1-Subject, Electrical Engineering and Information Technology, Specialisation Medical Applications, (Version 2019)	Optional	2.
Master, 1-Subject, Electrical Engineering and Information Technology, Specialisation Power Electronics, Control and Communications in Energy Systems, (Version 2019)	Optional	2.
Master, 1-Subject, Electrical and Information Engineering, (Version 2015)	Optional	2.
Master, 1-Subject, Electrical Engineering and Business Management, (Version 2022)	Optional	2.
Master, 1-Subject, Electrical Engineering and Business Management, (Version 2019)	Optional	2.
Master, 1-Subject, Electrical Engineering and Business Management, (Version 2017)	Optional	2.
Master, 1-Subject, Electrical Engineering and Business Management, (Version 2015)	Optional	2.

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Module Name	Module Code
Advanced Methods in Nonlinear Control	etit6021-01a
Module Coordinator	
Prof. Dr.-Ing. habil. Thomas Meurer	
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	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
Independent Study	105
Teaching Language	English

Module Courses			
Course Type	**Course Name**	**Compul-sory/Optional**	**SWS**
Lecture	Advanced Methods in Nonlinear Control	Compulsory	2
Exercise	Advanced Methods in Nonlinear Control	Compulsory	1

Examination(s)				
Examination Name	**Type of Examination**	**Evaluation**	**Compulsory / Optional**	**Weighting**
Oral Examination: Advanced Methods in Nonlinear Control	Oral Examination	Graded	Compulsory	100

Course Content

- Lyapunovs first and second method
- Passivity-based control
- Backstepping control
- Extremun-seeking control
- Sliding-mode control

Learning Outcome

The students are able to explain the first and second method of Lyapunov and apply them for the stability analysis of nonlinear systems. They are able to decide for an appropriate control design method on the basis of the structural properties of a given system. The students can design controllers for nonlinear systems using different approaches and perform closed-loop stability analysis. They are able to implement basic numerical solvers for performing simulations of nonlinear control systems and discuss the performance of the closed-loop system.

Reading List

- Freeman, R., Kokotovic, P.V., Robust Nonlinear Control Design, Birkhäuser.
- Sepulchre, R., Jankovic, M., Kokotovic, P.V., Constructive Nonlinear Control, Springer-Verlag.
- van der Schaft, A., L2-Gain and Passivity Techniques in Nonlinear Control.
- Krstic, M., Kanellakopoulos, I., Kokotovic, P. V., Nonlinear and Adaptive Control Design, Wiley.

Use	Compulsory / Optional	Semester
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, Electric Vehicle Propulsion and Control, (Version 2020)	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
Applied Nonlinear Dynamics	etit6004-01a
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	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
Independent Study	105
Teaching Language	English

Recommended Requirements

- Nonlinear Control Systems (Module etit5013-01a)

Module Courses

Course Type	Course Name	Compul-sory/Optional	SWS
Lecture	Applied Nonlinear Dynamics	Compulsory	2
Exercise	Applied Nonlinear Dynamics	Compulsory	1

Examination(s)

Examination Name	Type of Examination	Evaluation	Compulsory / Optional	Weighting
Oral Examination: Applied Nonlinear Dyna-mics	Oral Examination	Graded	Compulsory	100

Course Content

The students are able to explain fundamental system properties using terminology from linear and nonlinear system analysis. They can analyze the stability properties and existence conditions for stationary and periodic solutions of dynamical systems using local and non-local approaches. The students know the differences between the basic types of bifurcations in one and two-dimensional continuous and discrete-time systems. They are able to implement basic numerical solvers for performing simulations of dynamical systems.

Learning Outcome

- Linear and nonlinear dynamical systems
- Qualitative behavior of vector fields
- Local and non-local bifurcations
- Discrete-time nonlinear systems
- Introduction to deterministic chaos

Reading List

- A. Schaum: Applied Nonlinear Dynamics - Lecture notes.
- S. Strogatz: Nonlinear Dynamics and Chaos: with applications to physics, biology, chemistry, and engineering, Pereus Books.
- L. Perko: Differential Equations and Dynamical Systems, Springer.
- J. Hale, H. Kocak: Dynamics and Bifurcations, Springer.
- S. Lynch: Dynamical Systems with Applications using Mathematica, Birkhäuser.
- R. Abraham: C. Shaw: Dynamics: The Geometry of Behavior, Addison-Wesley.
- S. Wiggins: Introduction to Applied Nonlinear Systems and Chaos, Springer.
- S. Sastry: Nonlinear Systems: Analysis, Stability, and Control, Springer.

Use	Compulsory / Optional	Semester
Bachelor, 1-Subject, Business Economics, (Version 2014)	Optional	1.
Bachelor, 1-Subject, Economics, (Version 2014)	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, Electric Vehicle Propulsion and Control, (Version 2020)	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.

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Module Name	Module Code
Battery Technologies, Manufacturing, Modelling, Control and Integration in Power Electronics	etit6034-02a
Module Coordinator	
Prof. Dr.-Ing. Marco Liserre	
Organizer	
Department of Electrical and Information Engineering - Automatic Control	
Department of Electrical and Information Engineering - Power 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	30 hours
Independent Study	120 hours
Teaching Language	English

Examination(s)				
Examination Name	**Type of Examination**	**Evaluation**	**Compulsory / Optional**	**Weighting**
Oral Examination: Battery Technologies, Manufacturing, Modelling, Control and Integration in Power Electronics	Oral Examination	Graded	Compulsory	-

Course Content
Several topics related to battery technologies, modeling and control and power conversion and applications, such as: • Materials for Li-Ion Batteries • Design and Production of Lithium Batteries • Electrochemical Simulation • Modeling and State Estimation • Battery integration in power electronics • Battery storage systems for renewable energies

Learning Outcome
The students attending this module can formulate a research question for independent analysis in the area of battery technologies and for battery integration. The students can perform a literature search and organize publications by relevance. They can summarize and explain the content of the scientific publications. The students can compare the results and assess them critically. The students can present the results, discuss them and recommend further research steps on the research topic.
Reading List
Provided after definition and selection of topics

Use	Compulsory / Optional	Semester
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, Electric Vehicle Propulsion and Control, (Version 2020)	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
Computational Electromagnetics	etit6005-01a
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	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
Independent Study	105
Teaching Language	English

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

Examination(s)				
Examination Name	**Type of Examination**	**Evaluation**	**Compulsory / Optional**	**Weighting**
Oral Examination: Computational Electro-magnetics	Oral Examination	Graded	Compulsory	100

Course Content

Maxwell‘s equations:
Time- and frequency domain, constitutive equations for different media: non-linear, inhomogeneous, anisotropic, dispersive

Finite Differences:
1D example, Finite-Difference Time-Domain (FDTD) method, discretization, Yee grid, leap-frog algorithm, stability, numerical dispersion, simulation of free-space scattering problems, perfectly matched layer (PML), sub-celling, treatment of dispersive media, development of an 2-D FDTD source code

Finite Elements: 1D example:
linear form functions, Galerkin method, Ritz method; 2D and 3D problems: discretization, scalar und vector linear elements, typical problems and formulations

Iteratively solving a system of linear equations:
Splitting methods, Krylov subspace methods

Learning Outcome

The students are able to explain the most common local numerical methods for the computation of electromagnetic fields.They have the ability to numerically model and solve corresponding practical electromagnetic problems. They can judge the properties of commercially available CEM software and decide for the most suitable CEM software for a given problem.

Reading List

- Taflove, A.: Computational Electrodynamics: The Finite-Difference Time-Domain Method. Boston-London: Artech House, 1995
- Kunz, K.S.; Luebbers, R.J.: The Finite Difference Time Domain Method in Electromagnetics. Boca Raton: CRC Press, 1993
- Jin, J.: The Finite Element Method in Electromagnetics. New York - Chichester: Wiley Interscience, 1993
- Press, H.P.; Teukolsky, S.A.; Vetterling,, W.T.; Flannery, B.P.: Numerical Recipes (2nd ed.). Cambridge University Press, 1992.

Use	Compulsory / Optional	Semester
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.

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Module Name	Module Code
Control of PDE Systems	etit6006-01a
Module Coordinator	
Prof. Dr.-Ing. habil. Thomas Meurer	
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	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
Independent Study	105
Teaching Language	English

Recommended Requirements

- Nonlinear Control Systems (Module etit5013-01a)

Module Courses

Course Type	Course Name	Compul-sory/Optional	SWS
Lecture	Control of PDE Systems	Compulsory	2
Exercise	Control of PDE Systems	Compulsory	1

Examination(s)

Examination Name	Type of Examination	Evaluation	Compulsory / Optional	Weighting
Oral Examination: Control of PDE Systems	Oral Examination	Graded	Compulsory	100

Course Content

- Introduction to the distributed parameter systems: Mathematical modeling, classification, solution techniques for partial differential equations
- Analysis and control design in frequency domain: input-output stability, output feedback control
- Analysis and control design in time domain: controllability and observability, stability theory, state feedback control, backstepping
- Flatness-based methods for trajectory planning and tracking control

Learning Outcome

The students have an in-depth understanding of control design methods for distributed parameter systems governed by partial differential equations. They understand the underlying mathematical concepts and are able to apply these to new problems. The students are able to analyze control theoretic properties for distributed parameter systems. They have a comprehensive understanding of the control design methods and are able to independently apply these methods to control problems involving partial differential equations.

Reading List

- T. Meurer: Control of PDE Systems, Lecture notes.
- R. Curtain, H. Zwart: An Introduction to Infinite-Dimensional Linear Systems Theory, Springer-Verlag, New York.
- M. Krstic, A. Smyshlyaev: Boundary Control of PDEs: A Course on Backstepping Designs, SIAM, Philadelphia.
- Z. Luo, B. Guo, O. Morgül: Stability and Stabilization of Infinite Dimensional Systems with Applications, Springer-Verlag, London.
- T. Meurer: Control of Higher-Dimensional PDEs: Flatness and Backstepping Designs, Springer-Verlag, Berlin.

Use	Compulsory / Optional	Semester
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, Electric Vehicle Propulsion and Control, (Version 2020)	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.

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Module Name	Module Code
Design and Analysis of Selected Fundamental CMOS Circuits	etit6019-01a
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	30
Independent Study	120
Teaching Language	English

Module Courses			
Course Type	**Course Name**	**Compul-sory/Optional**	**SWS**
Lecture	Design and Analysis of Selected Fundamental CMOS Circuits	Compulsory	2

Examination(s)				
Examination Name	**Type of Examination**	**Evaluation**	**Compulsory / Optional**	**Weighting**
Presentation: Design and Analysis of Selected Fundamental CMOS Circuits	Presentation	Graded	Compulsory	100

Course Content

Students are introduced to the design and analysis of several elemental CMOS integrated circuits. The course begins with a discussion of differential amplifiers and related design aspects, including the differential pair with passive load and active load, common-mode feedback, push-pull amplifier, source-follower, folded cascode, and instrumentation amplifier. The students learn how to apply a simplified expression for the channel-length modulation effect for resistance estimation. Furthermore, they understand the circuit principles of inductorless oscillator circuits (Wien-Bridge Oscillator, Gm-C quadrature oscillator, ring oscillator, relaxation oscillator). Approaches to on-chip amplitude stabilization are discussed. Further structures of interest are circuits for NTAT, PTAT and bandgap reference generation. The students will be able to predict circuit performance using SPICE-based simulation software.

Learning Outcome

The students comprehend the design concepts for essential analog integrated circuits (amplifier, oscillator, etc.) and the available design choices. They are aware of typical design trade-offs and of the design parameter space. The students are able to simulate CMOS integrated circuits using a SPICE-based software and employ engineering simplifications for design planning. They also obtain the skills to design the key circuit parameters and predict circuit performance. Students are also able to present a short engineering topic to a scientific audience

Reading List

- Lecture handouts, including lecture slides
- P. E. Allen, D. R. Holberg, CMOS Analog Circuit Design, 2nd ed., London, U.K.: Oxford Univ. Press, 2002

Use	Compulsory / Optional	Semester
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
Design Space Exploration for Unmanned Systems	etit6032-01a
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 winter semesters
Workload per ECTS Credit	30 hours
Total Workload	150 hours
Contact Time	60
Independent Study	90
Teaching Language	English

Module Courses			
Course Type	**Course Name**	**Compul-sory/Optional**	**SWS**
Lecture	Design Space Exploration for Unmanned Systems	Compulsory	2
Exercise	Design Space Exploration for Unmanned Systems	Compulsory	2

Examination(s)				
Examination Name	**Type of Examination**	**Evaluation**	**Compulsory / Optional**	**Weighting**
Oral Examination: Design Space Exploration for Unmanned Systems	Oral Examination	Graded	Compulsory	100

Course Content

Unmanned systems have to handle uncertainties properly in order to assure their effective operation in real environments. These uncertainties are modelled for their sensors, actuators, environments, and objectives. Finding the best unmanned system implies that an evaluation of unmanned systems is possible, despite the fact that the uncertainties can vary in time and space and that they can be countered by adequate signal processing and clever behaviors whose exact implementations depend on prior knowledge about these variations. This, already, results in very high-dimensional optimization space for each possible hardware design selection. This lecture gives an overview of tools to handle the complexity of such design space exploration. It focusses on sensor data fusion architectures, and it demonstrates the capabilities of the tools by hands-on exercises on an example implementation of a system tasked for object classification by active acoustic sensing.

Lecture outline:

1
- L: Introduction
- E: Preparation of installation of useful software packages

2
- L: Causal description & uncertainty propagation
- E: Fokker-Planck-Diffusion & Polynomial Chaos

3
- L: Sensors & belief
- E: Partially Observable Markov Decision Process (POMDP)

4
- L: Data fusion & uncertainty absorbing behavior
- E: Bayesian methods

5
- L: System-of-systems design, Verification & Validation
- E: Formal methods

6
- L: Effectiveness, robustness, and efficiency
- E: Bayesian decision making

7
- L: Top-down view
- E: Unified Architecture Framework (UAF)

8
- L: Linkage to bottom-up view
- E: SysML

9
- L: Acausal description
- E: Acoustic simulation

10
- L: Application
- E: Ellipsoid detection

11
- L: Implementation
- E: Probability Hypothesis Density (PHD) tracking

12
- L: Instance of ontology
- E: Sensor input to actuator output

13
- L: Summary & Conclusion
- E: Benefits of the Design Space Exploration approach

14
- L: Outlook
- E: Comparison Deep Learning vs. Model-based Learning

Learning Outcome
Students can apply a model-based approach to find and describe the origins of uncertainty when designing unmanned systems. They know the interfaces between system modules dealing with uncertainty in measurements, decision making, planning, and control. Students can apply the associated mathematical framework to real-world problems.
Reading List
System Engineering: • J. Holt and S. Perry: SysML for System Engineering, IET Books, 2020 Data Fusion: • W. Koch: Tracking and Sensor Data Fusion, Springer, 2014 Probabilistic Models: • D. Koller and N. Friedman: Probabilistic Graphical Models, MIT Press, 2010

Use	**Compulsory / Optional**	**Semester**
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
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.

Module Name	Module Code
Electric Drives	etit6007-01a
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	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	52,5
Independent Study	97,5
Teaching Language	English

Module Courses			
Course Type	**Course Name**	**Compul-sory/Optional**	**SWS**
Lecture	Electric Drives	Compulsory	2
Exercise	Electric Drives	Compulsory	1,5

Examination(s)				
Examination Name	**Type of Examination**	**Evaluation**	**Compulsory / Optional**	**Weighting**
Oral Examination: Electric Drives	Oral Examination	Graded	Compulsory	100

Course Content

Electric drives are a key technology for reducing energy consumption of industrial processes, for modern wind energy power generation and for enabling green-transportation (electric and hybrid vehicles, electric trains, more electric ships and airplanes). Moreover electric drives are starting to be widespread making easier everyday life with automation and robotics. The course starts from a deep modeling phase of ac electrical machines, nowadays the most used. Then the field oriented control of the asynchronous and synchronous (Permanent Magnet) machines are treated in details due to their wide use and importance in modern electric drives. Exercises are carried out with CAE-tools (Matlab/Simulink).

Topics overview:

- Space vector representation of electrical machines
- Dynamic model of the synchronous machine
- Dynamic model of the asynchronous machine
- Overview of PWM modulation
- Overview of current control techniques
- Vector control of the permanent magnet synchronous machine: Current control loop and speed control loop
- Vector control of the asynchronous machine: Flux observer

Learning Outcome

The students have in-depth understanding on the control of electric drives. The students can formulate the dynamical model of the most adopted electrical machines in electric drives, and consequently choice the design of their controllers. The students have developed experience in the control design of electrical machines through simulation software, like Matlab, and have validated the control strategies in Simulink environment.

Reading List

- Ned Mohan, “Electric Machines and Drives: A First Course”, Wiley 2012.
- Werner Leonhard, “Control of electric drives”, Springer 2001.

Use	Compulsory / Optional	Semester
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, Electric Vehicle Propulsion and Control, (Version 2020)	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
Enabling Technologies for the Industrial Internet of Things	etit6031-01a
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	5
Evaluation	Graded
Duration	One Semester
Frequency	Takes place on an irregular basis
Workload per ECTS Credit	30 hours
Total Workload	150 hours
Contact Time	60
Independent Study	90
Teaching Language	English

Module Courses			
Course Type	**Course Name**	**Compul-sory/Optional**	**SWS**
Lecture	Enabling Technologies for the Industrial Internet of Things	Compulsory	2
Exercise	Enabling Technologies for the Industrial Internet of Things	Compulsory	1
Practical exercise	Enabling Technologies for the Industrial Internet of Things	Compulsory	1

Examination(s)				
Examination Name	**Type of Examination**	**Evaluation**	**Compulsory / Optional**	**Weighting**
Written Examination: Enabling Technologies for the Industrial Internet of Things	Written Examination	Graded	Compulsory	100

Course Content

Day 1
- 9-10 S. Saponara, G. Manara, “Introduction on Electronics and Electromagnetics for wireless transceivers, systems and networks in IoT applications”
- 10-13 G. Iannaccone, “Passive RFID systems and techniques for energy scavenging” Part I
- 13-14.30 lunch
- 14.30-17.30 G. Iannaccone, “Passive RFID systems and techniques for energy scavenging” Part II

Day 2
- 9-13 S. Genovesi, F. Costa, “Chipless RFID for tags and sensors design”
- 13-14.30 lunch
- 14.30-17.30 P. Nepa, G. Manara, “Location sensing with RFID transponders”

Day 3
- 9-13 S. Saponara, B. Neri “Integrated circuits and VLSI architectures for mm-wave/RF wireless transceivers in IoT applications (Wireless Sensor/Actuator Networks, Radars, ...) Part I
- 13-14.30 lunch
- 14.30-17.30 F. Baronti, B. Neri, hands-on lab session, “Computer Aided Design (CAD) and verification of mm-wave/RF wireless transceivers”, Part I

Day 4
- 9-13 S. Saponara, B. Neri “Integrated circuits and VLSI architectures for mm-wave/RF wireless transceivers in IoT applications (Wireless Sensor/Actuator Networks, Radars, ..) Part II
- 13-14.30 lunch
- 14.30-17.30 F. Baronti, B. Neri, hands-on lab session, “Computer Aided Design (CAD) and verification of mm-wave/RF wireless transceivers”, Part II

Day 5
- 9-13 M. Macucci, “Ultra-low-power devices (e.g. tunnel FET), and application of new materials (e.g. graphene) to antennas above 100 GHz and RF&mm-Wave circuits”
- 13-14.30 lunch
- 14.30-17.30 L. Klinkenbusch, “Electromagnetic propagation and EMC/EMI issues for IoT” Part I

Day 6
- 9-13 L. Klinkenbusch, “Electromagnetic propagation and EMC/EMI issues for IoT” Part II
- 13-14.30 lunch
- 14.30-17.30 G. Manara, P. Nepa, "Near-field focused antennas for short-range wireless systems optimized for identification, communication, power transfer, detection and sensing"

Day 7
- 9-13 S. Giordano, “Networking protocols and architectures for IoT and Cyber Physical Systems” Part I
- 13-14.30 lunch
- 14.30-16.30 S. Giordano, “Networking protocols and architectures for IoT and Cyber Physical Systems” Part II

Day 8
- Final course examination

Learning Outcome

The students have an understanding of the main technologies needed for the Internet of Things and they are familiar with the issues and problems of these technologies. The students are competent to judge the applicability of the internet-of-things technologies for new applications. They are able to design an internet-of-things application.

Reading List
• "Enabling Technologies for the Internet of Things: Wireless Circuits, Systems and Networks", 2018, Editor: S. Saponara, University of Pisa, Italy, ISBN: 9788793609747 • IEEE Internet of Things Journal, Vol. 1, No. 1, Feb 2014 (entire issue) • J. Rifkin, The Zero Marginal Cost Society: The Internet of Things, the Collaborative Commons, and the Eclipse of Capitalism. Macmillan, Reprint 2015
Additional Information
Website: https://www.unipi.it/index.php/engineering/item/6869-summer-school-internet-of-things . Note that there is a (limited) number of free places for students from Kiel University! Please contact Prof. Klinkenbusch: Klinkenbusch@tf.uni-kiel.de

Use	**Compulsory / Optional**	**Semester**
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
Fiber-optic Communication Networks	etit6008-01a
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
Independent Study	90
Teaching Language	English

Module Courses			
Course Type	**Course Name**	**Compul-sory/Optional**	**SWS**
Lecture	Fiber-optic Communication Networks	Compulsory	2
Exercise	Fiber-optic Communication Networks	Compulsory	2

Examination(s)				
Examination Name	**Type of Examination**	**Evaluation**	**Compulsory / Optional**	**Weighting**
Oral Examination: Fiber-optic Communication Networks	Oral Examination	Graded	Compulsory	100

Course Content
1. Fundamentals of optical communications 2. Protocols used in optical networks 3. Network architectures 4. Monitoring, failure localization & protection switching 5. Network simulation and optimization

Learning Outcome

The students can explain the fundamental building blocks used in fiber optical communication networks and describe the physical properties of light propagation in optical fibers, major network elements, the network architecture as well as protocols and network management. They are able to use central methods to analyse practical networking, system and operational aspects and are able to optimize them. Finally, they are able to explain modern principles such as software-defined networking and network function virtualization.

Reading List

- R. Ramaswami, “Optical Networks.:A Practical Perspective”, Morgan Kaufmann, 2009.
- S. Pachnicke, “Fiber-Optic Transmission Networks”, Springer, 2011.
- B. Mukherjee, “Optical WDM Networks“, ISBN: 0-387-29055-9

Use	Compulsory / Optional	Semester
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.

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Module Name	Module Code
Fundamentals of Acoustics	etit6024-01a
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 winter semesters
Workload per ECTS Credit	30 hours
Total Workload	150 hours
Contact Time	60 hours
Independent Study	90 hours
Teaching Language	English

Recommended Requirements			
Previous knowledge about digital signal processing and linear systems.			
Module Courses			
Course Type	**Course Name**	**Compul-sory/Optional**	**SWS**
Lecture	Fundamentals of Acoustics	Compulsory	3
Exercise	Fundamentals of Acoustics	Compulsory	1

Examination(s)				
Examination Name	**Type of Examination**	**Evaluation**	**Compulsory / Optional**	**Weighting**
Oral Examination: Fundamentals of Acoustics	Oral Examination	Graded	Compulsory	100

Course Content

1. Fundamentals of Vibrations (Mechanical oscillators, Electro-mechanic analogy, Vibrating string)
2. Theory of Sound Field (Basic equations, Simple sound sources, Reflection, Refraction, Absorption)
3. Sound and Systems (Resonators, Filters, Waveguides, Enclosed spaces, Diffuse sound field)
4. Transducers (Electroacoustic transduction, Radiation pattern, Hydroacoustic transducers)
5. Sound-Structure Interaction (Vibrating plate, Sound radiation, Flow-induced noise, Quite structure design)
6. Ship Acoustics (Structure-borne sound, Interior noise, Transmission loss, Source level)
7. Acoustic Sensor Systems (Directivity, Antenna design, Hydroacoustic antennas, Interior flow noise)
8. Underwater Noise Measurement (Reverberation, Ambient noise, Ship noise, Noise mapping, Ocean monitoring)
9. Impulsive Underwater Noise (Construction noise, Wind turbines, Acoustics of air bubbles, Noise reduction)
10. Oceanographic Instruments (Acoustic Doppler current profiler, Seafloor acoustic systems, Acoustic tomography)

Learning Outcome

Knowledge
- Students acquire an in-depth knowledge on the principles of sound and vibrations and their applications in the field of underwater acoustics.

Capabilities
- Professional calculation of noise generation, propagation, and reduction.
- Evaluation of noise in marine environments.
- Conceptional design of acoustic measurements and instrumentation.
- Transfer of concepts between waterborne and airborne sound.

Competencies
- Design and analysis of acoustical systems.
- Assessment of the performance of these systems by theoretical analysis.

Reading List

- L. Kinsler, A. Frey, A. Coppens, J. Sanders: Fundamentals of Acoustics, Wiley, 2009
- J. Blauert, N. Xiang: Acoustics for Engineers, Springer 2008
- R. Lerch, G. Sessler, D. Wolf: Technische Akustik, Springer 2009 o M. Möser: Technische Akustik, Springer 2015
- R. Urick: Principles of Underwater Sound, McGraw-Hill 1975
- H. Medwin: Sounds in the Sea, Cambridge 2005
- J. Abshagen: Wasserschallmessungen, M. Möser (Hsg.), Springer 2018

Use	Compulsory / Optional	Semester
Master, 1-Subject, Digital Communications, (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.
Master, 1-Subject, Electrical Engineering and Business Management, (Version 2017)	Optional	1.
Master, 1-Subject, Electrical Engineering and Business Management, (Version 2015)	Optional	1.

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Module Name	Module Code
Grid Converters for Renewable Energy Systems	etit6009-01a
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	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	52,5
Independent Study	97,5
Teaching Language	English

Entry Requirements as Stated in the Examination Regulations
Admission to this the module requires the successful completion of the module "Leistungselektronik Grundlagen" (etit-111).

Module Courses

Course Type	Course Name	Compulsory/Optional	SWS
Lecture	Grid Converters for Renewable Energy Systems	Compulsory	2
Exercise	Grid Converters for Renewable Energy Systems	Compulsory	1,5

Examination(s)

Examination Name	Type of Examination	Evaluation	Compulsory / Optional	Weighting
Oral Examination: Grid Converters for Renewable Energy Systems	Oral Examination	Graded	Compulsory	100

Course Content

Grid-connected PWM converters are gaining increasing importance in view of a growing contribution of Distributed Power Generation Systems (DPGS) to the total power flow in the European electric grid. This is also owed to an increasing inflow from Renewable Energy Sources (RES).
After a review of the power electronics solutions used for Photovoltaic (PV) and Wind Turbine (WT) systems and an overview about modulation and current/voltage control techniques, the course focuses on the specific issues related to the connection of a PWM converter to the grid. Exercises are carried out with CAE-tools (Matlab/Simulink).

Topics overview:
- PV converter topologies
- WT converter topologies
- Overview of PWM modulation
- Overview of Current Control techniques
- Single-phase synchronization with the electrical grid
- Three-phase synchronization with the electrical grid
- Harmonic rejection
- Grid-filter design and resonance issues
- Parallel connection of power electronics converters

Learning Outcome

The students have in-depth knowledge in designing the power electronics interface for renewable energy systems to the electric grid. The students can recognize the different topologies associated to PV and wind energy systems and understand their working mechanism. The students can recognize, analyze and solve issues for electric grid interactive applications of these energy systems, such as synchronization, low frequency harmonic rejection and design of grid filters for reducing PWM harmonics. The students have developed experience in the control design of grid converters through simulation software, like Matlab, and have validated the control strategies in Simulink environment.

Reading List

Additional Information

- Remus Teodorescu, Marco Liserre, Pedro Rodriguez “Grid Converters for Photovoltaic and Wind Power Systems”, Wiley-IEEE, ISBN 8-0-470-05751-3, January 2011.

Use	Compulsory / Optional	Semester
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, Electric Vehicle Propulsion and Control, (Version 2020)	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
Integrated Circuit Design for Medical Applications	etit6018-01a
Module Coordinator	
Jun.-Prof. Dr. Andreas Bahr	
Organizer	
Department of Electrical and Information Engineering - Sensor System 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	60
Independent Study	90
Teaching Language	English

Module Courses			
Course Type	**Course Name**	**Compul-sory/Optional**	**SWS**
Lecture	Integrated Circuit Design for Medical Applications	Compulsory	2
Exercise	Integrated Circuit Design for Medical Applications	Compulsory	2

Examination(s)				
Examination Name	**Type of Examination**	**Evaluation**	**Compulsory / Optional**	**Weighting**
Written or Oral Examination: Integrated Circuit Design for Medical Applications	Written or Oral Examination	Graded	Compulsory	100

Course Content

This course introduces the concepts and procedures of analog integrated circuit design – with a special focus on medical electronic applications.

- Analog integrated circuits
- Biomedical signal generation and information transfer
- Design-flow (analog) and development procedures
- Circuit design techniques
- Simulation of analog integrated circuits, Spice
- Chip Engineering (floorplan, placement, routing, physical layout)
- Reliability issues during the design phase (Parasitic effects, Electro migration, Electrostatic Discharge)
- Amplifiers
- Amplifiers for biomedical applications
- Example of electronic implants

Learning Outcome

The students have an in#depth understanding of the design of analog integrated circuits as well as the design techniques and procedures. They know the major methods of design, simulation and layout of analog integrated circuits as well as the details and the use of a professional design frame work (Cadence). The students know how to simulate the electrical functionality if integrated circuits and how to consider further aspects like reliability aspects during the development phase.
They can use this knowledge to create new analog integrated circuits and enhance existing ones. They can perform analysis of highly complex integrated analog circuits and apply strategies for the efficient technological realization of complex integrated circuits.

Reading List

- R.J. Baker, CMOS: Circuit Design, Layout, and Simulation, Wiley-IEEE Press, 3rd edition, 2010, ISBN-10: 0470881321
- P. Alen; D. R. Holberg: CMOS analog circuit design, Oxford University Press Inc., 3rd revised edition, 2012, ISBN: 978-0-19-993742-4M.H. Hayes Statistical Signal Processing and Modeling, John Wiley and Sons, 1996

Use	Compulsory / Optional	Semester
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
Interface and Surface Analysis Methods in Materials Science	etit6010-01a
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
Independent Study	105
Teaching Language	English

Recommended Requirements

- Basics in Electronics
- Materials Science Lecture

Module Courses

Course Type	Course Name	Compul-sory/Optional	SWS
Lecture	Interface and Surface Analysis Methods in Materials Science	Compulsory	2
Exercise	Interface and Surface Analysis Methods in Materials Science	Compulsory	1

Examination(s)

Examination Name	Type of Examination	Evaluation	Compulsory / Optional	Weighting
Written or Oral Examination: Interface and Surface Analysis Methods in Materials Science	Written or Oral Examination	Graded	Compulsory	100

Course Content

Fundamentals:
Basics of interface and surface physics
Scanning probe methods:
Scanning tunneling microscopy and spectroscopy
Scanning force microscopy techniques (AFM,EFM,MFM, PFM, KPFM)
Spectroscopy methods:
X-ray diffraction
Rutherford backscattering spectrometry
Secondary ion mass spectroscopy
X-ray photoelectron spectroscopy
Reflection high-energy electron diffraction

Learning Outcome

Students get a broad overview over the most effective analytical methods used in thin film technology and are therefore able to characterize surfaces and interfaces including their physical and chemical principles. They are able to employ the appropriate surface analysis techniques in order to get specific information required in the field of thin film technology and analyze and interpret measured data in the field of surface characterization like XRD scans, XPS spectra, AFM/PFM images, etc.

Reading List

- Oberflächenphysik des Festkörpers, M. Henzler und W. Göpel, Teubner Studienbücher
- Surface Analysis: The principal techniques, Vickerman Gilmore, Wiley
- Surfaces and Interfaces, H. Lüth, Springer-Verlag
- Fundamentals of Surface and Thin Film Analysis, Feldmann et al., North-Holland

Use	Compulsory / Optional	Semester
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
Introduction to Radar Signal Processing and Algorithms	etit6025-01a
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	60
Independent Study	90
Teaching Language	English

Recommended Requirements

- A prior course in Digital Signal Processing or Digital Communications is recommended.

Module Courses

Course Type	Course Name	Compul-sory/Optional	SWS
Lecture	Introduction to Radar Signal Processing and Algo-rithms	Compulsory	3
Exercise	Introduction to Radar Signal Processing and Algo-rithms	Compulsory	1

Examination(s)

Examination Name	Type of Examination	Evaluation	Compulsory / Optional	Weighting
Written or Oral Examination: Introduction to Radar Signal Processing and Algorithms	Written or Oral Examination	Graded	Compulsory	100

Course Content

Modern radar systems are employed in a great variety of technical fields, ranging from aeronautical applications (e.g., for airport surveillance) to automotive applications (e.g., for driver assistance systems). Remote sensing and space-borne ground mapping applications are further exciting fields, where radar plays a predominant role. Essentially, modern radar systems consist of an analog radio-frequency (RF) frontend (including the antenna system) and a software-oriented digital signal processing (DSP) unit. This course is devoted to the latter part and focuses on advanced digital signal processing techniques for modern radar applications, either implemented in software or in dedicated signal processors.

Content overview

- Radar system aspects and range prediction
- Modulation schemes and ambiguity function
- Detection theory for target objects in clutter
- Space-time adaptive processing (STAP)
- Synthetic-aperture radar (SAR)
- Future trends in radar (e.g. MIMO radar)

Learning Outcome

The students obtain specialized knowledge in the field of radar signal processing and algorithms for a variety of applications - in particular about state-of-the-art techniques, like synthetic-aperture radar (SAR) or multiple-input multiple-output (MIMO) radar. The knowledge conveyed is matched to a master level in the area of electrical and information engineering. Upon a successful completion of this course, students acquire skills to understand modern radar systems, to analyze the expected performance, and to design suitable radar waveforms for a given radar task (along with corresponding receiver algorithms). The course mainly covers elements of a classical interactive on-line lecture/exercise, but will also support phases of self-study based on special exercises and tutorial material.

Reading List

- M. Skolnik, Radar Handbook, 3rd Ed., McGraw-Hill, 2008
- F. Nathanson, Radar Design Principles, 2nd Ed., McGraw-Hill, 1991 (classic textbook)
- L. Blake, Radar Range-Performance Analysis, Artech House, 1986 (classic textbook)
- D. Barton, Radar System Analysis and Modeling, Artech House, 2005
- C. Jackowatz, Spotlight-Mode Synthetic Aperture Radar: A Signal Processing Approach, Springer, 1996
- R. Klemm, Principles of Space-Time Adaptive Processing, 3rd Ed., IET Radar, Sonar and Navigation Series, 2006

Use	Compulsory / Optional	Semester
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
Microcontroller and FPGA Technique for Power Electronics Applications	etit6033-01a
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	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
Independent Study	105
Teaching Language	English

Recommended Requirements

- Electric Drives (module etit6007-01a)
- Design of Power Electronics Converters (module etit5002-01a)
- M.Sc. Laboratory Digital Circuit Design (module etit-8009-01a)

Module Courses

Course Type	Course Name	Compul-sory/Optional	SWS
Lecture	Microcontroller and FPGA Technique for Power Electronics Applications	Compulsory	2
Exercise	Microcontroller and FPGA Technique for Power Electronics Applications	Compulsory	1

Examination(s)

Examination Name	Type of Examination	Evaluation	Compulsory / Optional	Weighting
Oral Examination: Microcontroller and FPGA Technique for Power Electronics Applications	Oral Examination	Graded	Compulsory	100

Course Content

Using microcontroller units is necessary basic for every field of technology. This lecture introduces principle and structure of MCUs and FPGAs, and how the MCUs and FPGAs work for applications in power electronics such as PWM converters used in renewable power generations and motor drives used in electric vehicles. The application refers mainly to power electronics, electrical drives and design of digital circuit. In the exercises, the content of the lecture will be implemented on microcontrollers. And In the simulations, essential modules for the control of PWM converter/inverters will be designed. Detail contents of the lecture are as follow:

- Overview of MCU and FPGA
- Memory map and DMA
- Timer, GPIO and Interrupt
- ePWM, eQEP for position/speed measurement
- ADC, DAC and Commincations (SCI, SPI, CAN)
- Basic Programming and actual applications on example
- Simulation (FPGA: design of essential modules)

Learning Outcome

The students learn about the principles, structure and functionality of microcontrollers (MCUs) and FPGAs. They will be able to use MCUs and FPGAs for applications in power electronics such as PWM converters used in renewable power generations and motor drives used in electric vehicles. Furthermore, they will be able to design essential modules to control electric drives and PWM converters.

Reading List

- Philippe Darche; Microprocessor 1-4; John Wiley & Sons, 2020.
- TMS320F2837xD Dual-Core Delfino Microcontrollers: Technical Reference Manual; Texas Instrument, 2019.

Use	Compulsory / Optional	Semester
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, Electric Vehicle Propulsion and Control, (Version 2020)	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
Microwave Circuits and Systems: Active Circuits	etit6011-01a
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 winter semesters
Workload per ECTS Credit	30 hours
Total Workload	150 hours
Contact Time	45
Independent Study	105
Teaching Language	English

Recommended Requirements			
Knowledge about microwave technology of a B.Sc., general knowledge about circuits.			
Module Courses			
Course Type	**Course Name**	**Compul-sory/Optional**	**SWS**
Lecture	Microwave Circuits and Systems: Active Circuits	Compulsory	2
Exercise	Microwave Circuits and Systems: Active Circuits	Compulsory	1

Examination(s)				
Examination Name	**Type of Examination**	**Evaluation**	**Compulsory / Optional**	**Weighting**
Oral Examination: Microwave Circuits and Systems: Active Circuits	Oral Examination	Graded	Compulsory	100

Course Content

- Active high frequency devices: Schottky / PIN / varactor diodes, bipolar transistors, field effect transistors, microwave integrated circuits, microwave tubes
- Microwave amplifier design circuits, small signal amplifiers, two-port power gains, stability, single-stage amplifier design, broadband amplifier design
- Power amplifiers: Characteristics, amplifier classes A to S, large-signal characterization, design of class A power amplifiers
- Oscillators: general analysis, oscillators using transistors, crystal oscillators, dielectric resonator oscillators, oscillators based on frequency synthesis, phase lock loops, direct digital synthesis, oscillator phase noise, frequency multipliers
- Mixers: Single-ended mixer, balanced mixer, image reject mixer, differential FET mixer and Gilbert cell mixer
- Design of active microwave circuits using software tools

Learning Outcome

The students have an in-depth understanding about the structure and function of active microwave components and circuits. They can apply the principles and procedures for the design of active microwave components and circuits. The students can design components regarding given system requirements. They are able to improve microwave components and create new ones. The students are able to explain complex radiofrequency systems.

Reading List

- D. M. Pozar: “Microwave Engineering”, 4th ed., Willey, 2011
- G. Gonzalez: “Microwave Transistor Amplifiers: Analysis and Design.” Prentice Hall, 1996
- S. C. Cripps: “RF Power Amplifiers for Wireless Communications.”, 2nd ed., Artech House, 2006
- A. Grebennikov and N. O. Sokal: “Switchmode RF Power Amplifiers.” Elsevier, 2007
- J. Helszajn: “Passive and Active Microwave Circuits”, Wiley & Sons, 1978

Additional German Reading

- Zinke, Brunswig: „Hochfrequenztechnik 2“, Springer
- Meinke, Gundlach: “Taschenbuch der Hochfrequenztechnik 2/3”, Springer

Use	Compulsory / Optional	Semester
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.

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Module Name	Module Code
Microwave Filters: Theory, Design, and Realization	etit6012-01a
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 winter semesters
Workload per ECTS Credit	30 hours
Total Workload	150 hours
Contact Time	45
Independent Study	105
Teaching Language	English

Module Courses			
Course Type	**Course Name**	**Compul-sory/Optional**	**SWS**
Lecture	Microwave Filters: Theory, Design, and Realization	Compulsory	2
Exercise	Microwave Filters: Theory, Design, and Realization	Compulsory	1

Examination(s)				
Examination Name	**Type of Examination**	**Evaluation**	**Compulsory / Optional**	**Weighting**
Written or Oral Examination: Microwave Filters: Theory, Design, and Realization	Written or Oral Examination	Graded	Compulsory	100

Course Content

- Introduction to microwave filters
- Basic network theory
- Design of lumped lowpass prototype networks
- Circuit transformation on lumped prototype networks
- Coupled resonator circuits
- TEM transmission line filters
- Introduction to waveguide filters
- Introduction to dielectric resonator filters
- Introduction to different filter technologies
- Computer aided design

Learning Outcome

The students have an in-deep understanding of filter synthesis techniques, various filter characteristics and realization approaches. They can calculate the parameters of lowpass prototype networks. They can perform transformations on the networks. They can design and analyse filters for different applications based on given specifications. The students are able to select appropriate filter technology with appropriate electrical characteristics for different scenarios.

Reading List

- I. C. Hunter, Theory and Design of Microwave Filters. London: IET, 2001 / 2006 reprint with new cover.
- R. J. Cameron, R. Mansour, and C. M. Kudsia, “Microwave Filters for Communication Systems: Fundamentals, Design and Applications.” Wiley, 2007.
- J.-S. Hong and M. J. Lancaster, Microstrip filters for RF/microwave applications. New York: Willey, 1st ed. 2001 /2nd ed. 2011.
- G. Matthaei, L .Young, and E. M. T. Jones, Microwave Filters, Impedance Matching Networks and Coupling Structures. Norwood, MA, McGraw-Hill, 1964.
- Relevant articles related to the topics.

Use	Compulsory / Optional	Semester
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
Modeling and Simulation of Complex Physical Systems	etit6035-01a
Module Coordinator	
Prof. Dr.-Ing. Jan Trieschmann	
Organizer	
Department of Electrical and Information Engineering - Theoretical Electrical 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 winter 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	Modeling and Simulation of Complex Physical Systems	Compulsory	2
Exercise	Modeling and Simulation of Complex Physical Systems	Compulsory	1

Examination(s)				
Examination Name	**Type of Examination**	**Evaluation**	**Compulsory / Optional**	**Weighting**
Oral Examination: Modeling and Simulation of Complex Physical Systems	Oral Examination	Graded	Compulsory	-

Course Content

- Fundamental concepts of modeling of complex physical systems
- Dynamical laws of physical systems • Dimensional and scale analyses
- Fundamentals of Python for numerical simulations
- Description with ordinary and partial differential equations
- Fundamentals of numerical solutions of differential equations
- Single and multi-particle simulations
- Monte Carlo techniques and random walks
- Dimensionality reduction and principal component analysis
- Linear regression and Gaussian processes
- Data driven modeling and artificial neural networks
- Physics-informed neural networks

Learning Outcome

Students know the fundamental concepts of mathematical modeling of complex physical systems. They are familiar with different modeling and numerical simulation techniques. They understand the benefits, drawbacks, and applicability of the individual concepts – from classical numerical solutions over Monte Carlo methods to data driven and machine learning approaches. They are able to design and implement corresponding computational algorithms.

Reading List

- K.F. Riley, M.P. Hobson, S.J. Bence, Mathematical Methods for Physics and Engineering (Cambridge University Press, 2006)
- J.D. Logan, Applied Mathematics (Wiley, 2006)
- L. Susskind, G.E. Hrabovsky, Classical Mechanics: The Theoretical Minimum (Penguin Books, 2013)
- I.H. Hutchinson, A Student’s Guide to Numerical Methods (Cambridge University Press, 2015)
- A.L. Garcia, Numerical Methods for Physics (Prentice Hall, 1999)
- F. Chollet, Deep Learning with Python (Manning, 2018)
- M. Nielsen, Neural Networks and Deep Learning (Determination Press, 2015), online book: http://neuralnetworksanddeeplearning

Use	Compulsory / Optional	Semester
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
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.

Module Name	Module Code
Numerical Methods for Partial Differential Equations (Profilbildung)	mathNumPDEp-01a
Module Coordinator	
Organizer	
Faculty	
Faculty of Mathematics and Natural Sciences	
Examination Office	

ECTS Credits	10
Evaluation	Graded
Frequency	
Teaching Language	German

Examination(s)				
Examination Name	**Type of Examination**	**Evaluation**	**Compulsory / Optional**	**Weighting**
Written or Oral Examination: Numerical Methods for Partial Differential Equations (Profilbildung)	Written or Oral Examination	Graded	Compulsory	-

Course Content
Learning Outcome
Reading List

Use	Compulsory / Optional	Semester
Master, 1-Subject, Electrical and Information Engineering, (Version 2022)	Optional	2.
Master, 1-Subject, Electrical and Information Engineering, Specialisation Automation and Control, (Version 2022)	Optional	2.
Master, 1-Subject, Electrical and Information Engineering, Specialisation Devices and Circuits, (Version 2022)	Optional	2.
Master, 1-Subject, Electrical and Information Engineering, Specialisation Digital Communications, (Version 2022)	Optional	2.
Master, 1-Subject, Electrical and Information Engineering, Specialisation Medical Applications, (Version 2022)	Optional	2.
Master, 1-Subject, Electrical and Information Engineering, Specialisation Power Electronics, Control and Communications in Energy Systems, (Version 2022)	Optional	2.
Master, 1-Subject, Electrical Engineering and Information Technology, (Version 2019)	Optional	2.
Master, 1-Subject, Electrical Engineering and Information Technology, Specialisation Automation and Control, (Version 2019)	Optional	2.
Master, 1-Subject, Electrical Engineering and Information Technology, Specialisation Devices and Circuits, (Version 2019)	Optional	2.
Master, 1-Subject, Electrical Engineering and Information Technology, Specialisation Digital Communications, (Version 2019)	Optional	2.
Master, 1-Subject, Electrical Engineering and Information Technology, Specialisation Medical Applications, (Version 2019)	Optional	2.
Master, 1-Subject, Electrical Engineering and Information Technology, Specialisation Power Electronics, Control and Communications in Energy Systems, (Version 2019)	Optional	2.
Master, 1-Subject, Electrical and Information Engineering, (Version 2015)	Optional	2.
Master, 1-Subject, Physics, (Version 2017)	Optional	2.
Master, 1-Subject, Physics, (Version 2007)	Optional	2.
Master, 1-Subject, Electrical Engineering and Business Management, (Version 2022)	Optional	2.
Master, 1-Subject, Electrical Engineering and Business Management, (Version 2019)	Optional	2.

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Module Name	Module Code
Numerical Simulation of Analog and Digital Communication Systems	etit6022-01a
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 winter semesters
Workload per ECTS Credit	30 hours
Total Workload	150 hours
Contact Time	60
Independent Study	90
Teaching Language	English

Module Courses			
Course Type	**Course Name**	**Compul-sory/Optional**	**SWS**
Lecture	Numerical Simulation of Analog and Digital Communi-cation Systems	Compulsory	3
Exercise	Numerical Simulation of Analog and Digital Communi-cation Systems	Compulsory	1

Examination(s)				
Examination Name	**Type of Examination**	**Evaluation**	**Compulsory / Optional**	**Weighting**
Oral Examination: Numerical Simulation of Analog and Digital Communication Systems	Oral Examination	Graded	Compulsory	100

Course Content

Introduction:
- Numerical Simulation as method of investigation
- Comparison with other methods of investigation (experiments, theoretical modeling)

Basics:
- Description of communication systems by means of block diagrams, implementation of block diagrams into code
- Appropriate programming languages for local applications and distributed systems
- Signal sources (generators for random numbers, PRBS, PRMS)
- Signal analysis (measurement of S/N for analog systems, evaluation of bit error probability for digital systems, estimation of power spectrum density)
- Implementation of linear systems

Applications:
- Simulation of analog systems (e.g. speech processing)
- Simulation of digital systems (e.g. optical high-speed transmission systems)
- Parallel algorithms for efficient simulation on multi-core computers
- Processing on distributed systems

Learning Outcome

The students have a clear understanding of the potential of numerical simulation as flexible and cost-efficient tool for investigation into arbitrary communication systems. They are able to transfer real systems into computer code. They have a good overview on how to implement different elements of communication systems, such as signal generators and filters, and they can select suitable algorithms depending on their simulation scenario. For their simulation applications, they know which approaches for evaluation are appropriate. Finally, they have basic knowledge in the field of programming techniques for efficient use of today's computer hardware and of distributed systems.

Reading List

- M.C. Jeruchim, P. Balaban, and K.S. Shanmugan, Simulation of communication systems, New York, 1992.
- J. Leibrich, Modeling and simulation of limiting impairments on next generation's transparent optical WDM transmission systems with advanced modulation formats, Shaker, 2007

Use	Compulsory / Optional	Semester
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.

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Module Name	Module Code
Pattern Recognition and Machine Learning	etit6014-01a
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 winter semesters
Workload per ECTS Credit	30 hours
Total Workload	150 hours
Contact Time	60
Independent Study	90
Teaching Language	English

Module Courses			
Course Type	**Course Name**	**Compul-sory/Optional**	**SWS**
Lecture	Pattern Recognition and Machine Learning	Compulsory	3
Exercise	Pattern Recognition and Machine Learning	Compulsory	1
Prerequisits for Admission to the Examination(s)			
Prerequisites for the examination as stated in the Examination Regulations: Presentation			

Examination(s)				
Examination Name	**Type of Examination**	**Evaluation**	**Compulsory / Optional**	**Weighting**
Written or Oral Examination: Pattern Recognition and Machine Learning	Written or Oral Examination	Graded	Compulsory	100

Course Content

In this lecture the basics of pattern recognition are treated. Often schemes that are based on statistical optimization are utilized for these applications. The involved cost functions are matched to the specific applications.

Topic overview:

Preprocessing to reduce signal distortions
- Noise reduction
- Beamforming

Feature extraction and data compression

Pattern recognition and data regression
- Learning types: Unsupervised learning, Supervised learning, Reinformcement learning
- Codebooks
- Gaussian mixture models (GMMs)
- Artificial Neural Networks (ANNs): Multilayer perceptron, Convolutional neuronal networks (CNNs), Recurrent neural networks (RNNs), Autoencoder networks, Generative adversarial networks (GANs)
- Hidden Markov models (HMMs)

Selected applications of machine learning

Learning Outcome

Students can investigate different feature extraction and data compression techniques. They can understand the principles of machine learning schemes and compare the different concepts. Students apply the learned approaches to real-world problems.Furthermore, they can do research on related topics and present the results in a single person fashion or as a group work.

Reading List

Statistical signal theory:
- Papoulis: Probability, Random Variables, and Stochastic Processes, McGraw-Hill, 1965

Noise reduction, beamforming, adaptive filters:
- E. Hänsler, G. Schmidt: Acoustic Echo and Noise Control, Wiley, 2004
- S. Haykin: Adaptive Filter Theory, Prentice Hall, 2002
- A. Sayed: Fundamentals of Adaptive Filtering, Wiley, 2004

Speech signal processing:
- L. R. Rabiner, R. W. Schafer: Digital Processing of Speech Signals, Prentice Hall, 1978
- P. Vary, R. Martin: Digital Speech Transmission, Wiley, 2006
- L. R. Rabiner, R. W. Schafer: Introduction to Digital Speech Processing, Now, 2008

Use	Compulsory / Optional	Semester
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.

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Module Name	Module Code
Photonic Components	etit6015-01a
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	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	60
Independent Study	90
Teaching Language	English

Recommended Requirements

- Solid state physics
- Semiconductor devices

Module Courses

Course Type	Course Name	Compul-sory/Optional	SWS
Lecture	Photonic Components	Compulsory	2
Exercise	Photonic Components	Compulsory	2

Examination(s)

Examination Name	Type of Examination	Evaluation	Compulsory / Optional	Weighting
Oral Examination: Photonic Components	Oral Examination	Graded	Compulsory	100

Course Content

This course teaches the fundamentals and the design of photonic components based on the study of scientific publications. The following devices will be discussed:

- Light emitting diodes (LEDs)
- Organic light emitting diodes (OLEDs)
- Semiconductor lasers
- Optical switches
- Photo detectors
- Solar cells

Learning Outcome

The students can perform a literature search on a specific topic and summarize the content of scientific publications. They can explain the working principles of photonic components. They can analyze the performance of photonic devices and develop design choices for improvement. They can assess scientific publications critically.

Reading List

Mandatory literature

- A compilation of current research papers is handed out during the course.

Supplementary literature

- Schubert, E. F.: Light-emitting diodes, Cambridge University Press
- Würfel, P.: Physics of solar cells : from basic principles to advanced concepts, Wiley-Vch

Use	Compulsory / Optional	Semester
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
Renewable Energy Systems	etit6016-01a
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	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	52,5
Independent Study	97,5
Teaching Language	English

Module Courses			
Course Type	**Course Name**	**Compul-sory/Optional**	**SWS**
Lecture	Renewable Energy Systems	Compulsory	2
Exercise	Renewable Energy Systems	Compulsory	1,5

Examination(s)				
Examination Name	**Type of Examination**	**Evaluation**	**Compulsory / Optional**	**Weighting**
Oral Examination: Renewable Energy Systems	Oral Examination	Graded	Compulsory	100

Course Content

Due to the increasing energy demand, especially in emerging countries, and environmental concerns, the penetration of renewable energies and distributed electric power generation is changing the face of the power system. The course covers those aspects that do not imply a deep knowledge of power electronics converters but that are anyway crucial for their proper design.

Topics overview:

- Basic principles of wind and photovoltaic
- PV-system design and control procedure
- WT-system design and control procedure
- Islanding
- Microgrid
- HVDC
- Biomass & Bio CHP plant & Geothermal plants
- Energy storage systems basics & Modelling and economic analysis
- E-mobility and smart grid: Basics

Learning Outcome

The students have a general knowledge about how renewable energy systems (especially Wind and Photovoltaic) work, how they are structured and how they are organized in parks. The students understand the issues related to the interaction with the electric grid, and they are able to analyze national grid codes and international standards compliance, mostly regarding faults and islanding conditions regulations. The students can generally discuss on advanced topics related to ancillary services, use of storage, micro-grid operation, Combined Heat and Power plants, Bio-gas and special connection using High Voltage DC Transmission.

Reading List

- Remus Teodorescu, Marco Liserre, Pedro Rodriguez “Grid Converters for Photovoltaic and Wind Power Systems”, Wiley-IEEE, ISBN 8-0-470-05751-3, January 2011.
- Nicola Femia, Giovanni Petrone, Giovanni Spagnuolo, Massimo Vitelli: “Power Electronics and Control Techniques for Maximum Energy Harvesting in Photovoltaic Systems”, CRC Press, Taylor & Francis group, 2013, ISBN: 978-1-4665-6416-9.
- Komarnicki, Lombardi, Styczynski, “Electric Energy Storage Systems”, Springer 2017.

Use	Compulsory / Optional	Semester
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, Electric Vehicle Propulsion and Control, (Version 2020)	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
Swarm Communication and Navigation	etit6036-01a
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	52,5 hours
Independent Study	97,5 hours
Teaching Language	English

Module Courses			
Course Type	**Course Name**	**Compul-sory/Optional**	**SWS**
Lecture	Swarm Communication and Navigation	Compulsory	2
Exercise	Swarm Communication and Navigation	Compulsory	1,5

Examination(s)				
Examination Name	**Type of Examination**	**Evaluation**	**Compulsory / Optional**	**Weighting**
Oral Examination: Swarm Communication and Navigation	Oral Examination	Graded	Compulsory	-

Course Content

- Overview on swarm joint communication and navigation system
- Self-organized wireless network for robotic swarms
- Fundamental limits on and algorithms for swarm localization
- Swarm formation optimization for communication, localization and sensing
- Exercises, simulations and, optimally, hand-on with real data collected from space-analog swarm missions on volcanoes in Italy

Learning Outcome
After completion of the module students are able to design a joint communication and navigation system for a robotic swarm, apply information- and estimation theoretic methods for swarm analysis and optimization. They understand how the navigational information is extracted and flows inside the swarm. The students are able to transfer the learned knowledge to a wide range of applications and environments, which range from vehicular network, disaster management to deep sea and space exploration.
Reading List
Additional Information
• "Fundamentals of Statistical Signal Processing, Volume I: Estimation Theory"; Steven M. Kay; Prentice Hall Signal Processing Series, 1993; ISBN:0-13-345711-7 • "Digital Communications"; John G. Proakis; McGraw-Hill, 3rd Edition, 1995; ISBN 0-07-051726-6

Use	Compulsory / Optional	Semester
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
Time Series Analysis	etit6028-01a
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
Independent Study	105
Teaching Language	English

Module Courses			
Course Type	**Course Name**	**Compul-sory/Optional**	**SWS**
Lecture	Time Series Analysis	Compulsory	2
Exercise	Time Series Analysis	Compulsory	1

Examination(s)				
Examination Name	**Type of Examination**	**Evaluation**	**Compulsory / Optional**	**Weighting**
Oral Examination: Time Series Analysis	Oral Examination	Graded	Compulsory	100

Course Content

"Time series analysis" represents a field of statistical approaches to analysing time-resolved data sets. In this lecture a first introduction into this field will be provided, including examples of applications. A certain focus will be put on data sets with biomedical or neuroscience background.

Table of contents:

- Temporal correlations in data
- Frequency domain analysis
- Modeling and inverse problems
- Sets of linear equations, pseudoinverses
- Principal component analysis / independent component analysis
- Blind signal separation
- Maximum-likelihood estimation
- Entropy and mutual information
- Prediction of time series
- Whitening of residuals
- Dynamical systems
- Stochastic differential equations
- Deterministic chaos
- Autoregressive modelling
- State space modelling
- Reconstruction of strange attractors
- Fractal dimensions / Lyapunov exponents

Learning Outcome

The students are able to perform analyses of time series analysis. They can implement algorithms for time series analysis. Furthermore, the students have the ability to judge scientific publications critically .

Reading List

- G.E.P. Box & G.M. Jenkins (1970), Time series analysis: forecasting and control
- D.R. Brillinger (1981), Time series: data analysis and theory
- M.B. Priestley (1988), Non-linear and non-stationary time series analysis
- L. Ljung (1987), System identification: theory for the user
- J.D. Hamilton (1994), Time series analysis
- H. Kantz & T. Schreiber (1997), Nonlinear time series analysis
- H. Akaike (1999), The practice of time series analysis
- J. Durbin & S.J. Koopman (2001), Time series analysis by state space methods
- B. Schelter (2006), Handbook of time series analysis: recent theoretical developments and applications
- R.H. Shumway & D.S. Stoffer (2000), Time series analysis and its applications

Use	Compulsory / Optional	Semester
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
Tomographical Methods for Medicine	etit6017-01a
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	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
Independent Study	105
Teaching Language	English

Module Courses			
Course Type	**Course Name**	**Compul-sory/Optional**	**SWS**
Lecture	Tomographical Methods for Medicine	Compulsory	2
Exercise	Tomographical Methods for Medicine	Compulsory	1

Examination(s)				
Examination Name	**Type of Examination**	**Evaluation**	**Compulsory / Optional**	**Weighting**
Oral Examination: Tomographical Methods for Medicine	Oral Examination	Graded	Compulsory	100

Course Content

Introduction:
- Overview of medical imaging and tomographical methods

Electrical-Impedance Tomography (EIT):
- Principle of EIT
- Governing equations
- Solution of the inverse problem

Computer Tomography (CT):
- X-Ray principles and techniques
- System-theoretical basics (multi-dimensional Fourier transform, sampling, filtering)
- Radon transform
- Fourier-Slice theorem
- CT reconstruction techniques
- Different generations of CT configurations
- X-ray detectors
- Filtered back-projection

Magnetic resonance imaging (MRI):
- Principle of MRI
- Physical foundations (Magnetic dipole, proton spin, precession, Lamor frequency, quantum effects, spin-grid and spin-spin relaxation)
- Detection of relaxation constants T1 and T2, spin-echo
- Spatial resolution, selective stimulation, frequency- and phase coding techniques
- Contrast optimization, functional MRI
- Components of an MRI

Learning Outcome

The students understand the principles und manner of operation of tomographical methods in medicine so they are able to judge (as a precondition for designing) the technical systems necessary for tomographical apparatus. Furthermore they are able to develop new methods and systems in tomography.

Reading List

- J.L. Prince, J. Links: Medical Imaging Signals and Systems (2nd ed.). Pearson Education, 2014.
- P. Suetens: Fundamentals of Medical Imaging (2nd ed.), Cambridge University Press, 2009.

Use	Compulsory / Optional	Semester
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
Underwater Techniques	etit6026-01a
Module Coordinator	
Prof. Dr.-Ing. Sabah Badri-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
Independent Study	105
Teaching Language	English

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

Examination(s)				
Examination Name	**Type of Examination**	**Evaluation**	**Compulsory / Optional**	**Weighting**
Laboratory Task (Programming and Report) as well as Written or Oral Examination: Underwater Techniques	Other	Graded	Compulsory	100

Course Content

The main subjects of this course are:
- Underwater navigation and localization techniques
- Sonar signal processing algorithms and their implementation in software.

Contents overview:
- Properties of sound in water: Absorption, scattering, multipath propagation, natural and artificial noise sources.
- Sonar principles: Sonar equation, single-bream and multi-beam sonar systems, beamforming.
- Sonar signal processing: Localization and tracking of objects by means of 1D and 2D sonar signals. Sonar-based navigation, simulta- neous localization and mapping (SLAM).

Learning Outcome

The students have specialized knowledge in the field of underwater sound transmission and detection. Furthermore, they are able to understand modern navigation and localization techniques. The students can work on and solve tasks in the field of underwater techniques both independently and in a team-oriented manner.

Reading List

- L. Brekhovskikh, Y Lysanov, Fundamentals of Ocean Acoustics. Springer, 2003.
- W. S. Burdic, Underwater acoustic system analysis. Prentice Hall, 1991.
- X. Lurton, An Introduction to Underwater Acoustics: Principles and Applications. Springer Praxis Publishing, London, 2010.
- D. Ribas, P. Ridao, J. Neira, Underwater SLAM for Structured Environments Using an Imaging Sonar. Springer, 2010.

Use	Compulsory / Optional	Semester
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
Visible Light Communications	etit6030-01a
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 winter semesters
Workload per ECTS Credit	30 hours
Total Workload	150 hours
Contact Time	45
Independent Study	105
Teaching Language	English

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

Examination(s)				
Examination Name	**Type of Examination**	**Evaluation**	**Compulsory / Optional**	**Weighting**
Oral Examination: Visible Light Communi-cations	Oral Examination	Graded	Compulsory	100

Course Content

- Introduction to Visible Light Communications (VLC)
- Fundamentals of Illumination Engineering
- VLC Channel Modeling
- Modulation Schemes for Optical Wireless Communications
- Optical Multiple-Input Multiple-Output (MIMO) Techniques
- Optical Wireless Communication (OWC) Standardization
- Software-Defined Radio Concept and its Applications in OWC
- Photonic Devices and High-Speed Amplifiers
- Circuit Design Rules for OWC Transmitters and Receivers
- Selected VLC and Free-Space Optical (FSO) Applications
- Optical Rangefinding and Visible Light Positioning

Learning Outcome

The students will learn to understand optical wireless communication techniques, with emphasis on visible light communications, and to design new optical wireless systems. They can assess advanced system components. They are able to evaluate the overall system performance. The students will practice to read and to understand technical papers. They can critically assess latest developments.

Reading List

- P.A. Hoeher, "Visible Light Communications: Theoretical and Practical Foundations." Munich: Carl Hanser, 2019, Print-ISBN: 978-3-446-46206-9, E-Book-ISBN: 978-3-446-46172-7.
- P.A. Hoeher, "Visible Light Communications: Solutions Manual." Munich: Carl Hanser, 2019, E-Book-ISBN: 978-3-446-46303-5.
- Papers for additional reading will be distributed.

Use	Compulsory / Optional	Semester
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
Wide-bandgap Semiconductors	etit6020-01a
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	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
Independent Study	105
Teaching Language	English

Module Courses			
Course Type	**Course Name**	**Compul-sory/Optional**	**SWS**
Lecture	Wide-bandgap Semiconductors	Compulsory	2
Exercise	Wide-bandgap Semiconductors	Compulsory	1

Examination(s)				
Examination Name	**Type of Examination**	**Evaluation**	**Compulsory / Optional**	**Weighting**
Written or Oral Examination: Wide-bandgap Semiconductors	Written or Oral Examination	Graded	Compulsory	100

Course Content

- Semiconductor materials with wide band gap
- Characteristic deviceparameters (breakdown voltage, area-specific on-resistance)
- SiC Schottky diodes, pin diodes, MPS diodes
- SiC field-effect transistors, cascode circuit, SiC-MOSFETs, SiC-IGBTs
- GaN HEMTs and GaN MOSFETs
- Manufacturing processes
- Measurement method
- Application examples (PFC, resonant converters)

Learning Outcome
Students can describe the most important wide band gap power semiconductor devices. They know the basic structures, the operating principles as well as the characteristics and the limits of the devices. They can calculate the most important device dimensions and parameters of wide bandgap power semiconductor devices. They can solve typical scientific questions in the design of wide band gap power semiconductor devices. They can appropriately classify the devices according to their fields of application.
Reading List
• Baliga, B.J.: Gallium Nitride and Silicon Carbide Power Devices, World Scientific, 2017 • Lidow, A., Strydom, J. Rooij, M. Reusch, D.: GaN Transistors for Efficient Power Conversion, Wiley, 2015

Use	Compulsory / Optional	Semester
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, Electric Vehicle Propulsion and Control, (Version 2020)	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
Wireless Power Transfer and Smart Grid Communications	etit6029-01a
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
Independent Study	105
Teaching Language	English

Module Courses			
Course Type	**Course Name**	**Compul-sory/Optional**	**SWS**
Lecture	Wireless Power Transfer and Smart Grid Communica-tions	Compulsory	2
Exercise	Wireless Power Transfer and Smart Grid Communica-tions	Compulsory	1
Prerequisits for Admission to the Examination(s)			
Prerequisites for the examination as stated in the Examination Regulations: Presentation Since weekly exercises are replaced by individual presentations, each student must give a presentation before taking his/her oral examination in order to obtain a sufficient number of ECTS credits. Presentation topics will be distributed by the chair.			

Examination(s)				
Examination Name	**Type of Examination**	**Evaluation**	**Compulsory / Optional**	**Weighting**
Oral Examination: Wireless Power Transfer and Smart Grid Communications	Oral Examination	Graded	Compulsory	100

Course Content

- Simultaneous Wireless Information and Power Transfer (SWIPT)
- SWIPT Circuit Topologies
- Qi Standard for Wireless Power Charging
- Smart Grid Architectures
- Communication Standards Suitable for Smart Grids
- Powerline Communication
- Communication Aspects of Smart Metering

The module is offered in the form of an inverted classroom lecture. Every week, a new paper (frequently a tutorial) will be distributed to the participants. The students are expected to read the paper prior to the next lecture. In the first part of a lecture, the paper will usually be discussed in teams. Afterwards, the paper will be discussed at the black board. There will be no weekly exercises. Instead, each student is expected to give a presentation on a selected topic at the end of the semester. This presentation is mandatory as it replaces conventional exercises.

Learning Outcome

The students will learn to understand wireless power transfer and smart grid communication techniques. Since the module is an inverted classroom lecture, students learn to solve problems both independently as well as team-oriented. They can assess advanced system components. They are able to evaluate the over-all system performance. The students will be trained to search, to read, and to understand technical papers, to work in teams, and to give a presentation at the end of the semester. They can critically assess latest developments.

Reading List

Papers (mostly tutorials) will be distributed

Use	Compulsory / Optional	Semester
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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Name	Code
Seminars	etit
Organizer	
Faculty	
Faculty of Engineering	
Examination Office	

Evaluation	Not graded

Use	Compulsory / Optional	Semester
Master, 1-Subject, Electrical Engineering and Information Technology, (Version 2019)	Compulsory	.

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Module Name	Module Code
Seminar Advanced Topics in Microwave Technologies	etit7001-01a
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	Not graded
Duration	One Semester
Frequency	Only takes place during summer semesters
Workload per ECTS Credit	30 hours
Total Workload	150 hours
Contact Time	30
Independent Study	120
Teaching Language	English

Module Courses			
Course Type	**Course Name**	**Compul-sory/Optional**	**SWS**
Seminar	Seminar Advanced Topics in Microwave Technologies	Compulsory	2

Examination(s)				
Examination Name	**Type of Examination**	**Evaluation**	**Compulsory / Optional**	**Weighting**
Presentation and Paper: Seminar Advanced Topics in Microwave Technologies	Other	Not graded	Compulsory	-
Further Information on the Examination(s)				
The students' achievements are assessed in a composite examination.				

Course Content
Several advanced topics related to the research area of the Microwave Group, such as: • THz Integrated Circuits. • (Sub-)Millimeter-Wave/Quasi-Optical Techniques and Circuitry. • Planar and Waveguide Filters. • Electronically Tunable Filters. • Moisture Measurement Techniques. • RF-Based Security. • Magnetic Sensors. • Medical Sensors. • Radar. • Data (or Sensor) Fusion for Signal Enhancement.
Learning Outcome
The students can formulate a research question for independent analysis in the area of advanced topics in microwave technologies. The students can perform a literature search and organize publications by relevance. They can summarize and explain the content of the scientific publications. The students can compare the results and assess them critically. The students can present the results, discuss them and recommend further research steps on the research topic.
Reading List
• Scientific papers relevant to the research topic will be made available to students.

Use	**Compulsory / Optional**	**Semester**
Master, 1-Subject, Electrical and Information Engineering, (Version 2022)	Optional	1.
Master, 1-Subject, Electrical Engineering and Information Technology, (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
Seminar Analysis of Scientific Papers	etit7002-01a
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	Not graded
Duration	One Semester
Frequency	Only takes place during winter semesters
Workload per ECTS Credit	30 hours
Total Workload	150 hours
Contact Time	45
Independent Study	105
Teaching Language	English

Recommended Requirements

- Basics in Electronics
- Materials Science Lecture

Module Courses

Course Type	Course Name	Compul-sory/Optional	SWS
Seminar	Seminar Analysis of Scientific Papers	Compulsory	3

Examination(s)

Examination Name	Type of Examination	Evaluation	Compulsory / Optional	Weighting
Presentation and Paper: Seminar Analysis of Scientific Papers	Other	Not graded	Compulsory	-

Further Information on the Examination(s)

The students' achievements are assessed in a composite examination.

Course Content
Analysis and understanding of scientific papers related to the questions: • What is the subject of the paper? • Which significance the papers has in comparison to others work? • How plausible are the presented results? • Are their obvious faults? • How to read critical a scientific text?
Learning Outcome
Students are able to outline a typical paper in technical or scientific journals and classify papers with respect to journal impact factors. They can research literature unassisted and induct into a novel research and technological subject for preparing a written text to summaries the subject (paper) and the talk. They can critical read scientific paper and have ideas how to write the first own paper.
Reading List
• Guidelines: “How to present a scientific talk” and templates for the talk and the seminar work are available on the Kiel University OLAT learning platform in the material folder of this course.

Use	**Compulsory / Optional**	**Semester**
Master, 1-Subject, Electrical and Information Engineering, (Version 2022)	Optional	1.
Master, 1-Subject, Electrical Engineering and Information Technology, (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
Seminar Communications	etit7003-01a
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	Not graded
Duration	One Semester
Frequency	Takes place every semester
Workload per ECTS Credit	30 hours
Total Workload	150 hours
Contact Time	45
Independent Study	105
Teaching Language	English

Recommended Requirements			
Knowledge of basics obtained during bachelor’s course.			
Module Courses			
Course Type	**Course Name**	**Compul-sory/Optional**	**SWS**
Seminar	Seminar Communications	Compulsory	3
Prerequisits for Admission to the Examination(s)			
The students’ achievements are assessed in a composite examination.			

Examination(s)				
Examination Name	**Type of Examination**	**Evaluation**	**Compulsory / Optional**	**Weighting**
Presentation and Paper: Seminar Communications	Other	Not graded	Compulsory	-

Course Content
Selected topics of (optical) communications.

Learning Outcome
The students can formulate a research question for independent analysis in the area of optical communications. The students can perform a literature search and organize publications by relevance. They can summarize and explain the content of the scientific publications. The students can compare the results and assess them critically. The students can present the results, discuss them and recommend further research steps on the research topic.
Reading List
• Depending on respective seminar topics.

Use	Compulsory / Optional	Semester
Master, 1-Subject, Electrical and Information Engineering, (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 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 Digital Communications, (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
Seminar Integrated Systems and Photonics	etit7005-01a
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	5
Evaluation	Not graded
Duration	One Semester
Frequency	Takes place every semester
Workload per ECTS Credit	30 hours
Total Workload	150 hours
Contact Time	30
Independent Study	120
Teaching Language	English

Module Courses			
Course Type	**Course Name**	**Compul-sory/Optional**	**SWS**
Seminar	Seminar Integrated Systems and Photonics	Compulsory	2

Examination(s)				
Examination Name	**Type of Examination**	**Evaluation**	**Compulsory / Optional**	**Weighting**
Presentation: Seminar Integrated Systems and Photonics	Presentation	Not graded	Compulsory	-

Course Content
In the seminar current research topics in the area of integrated systems and photonics are presented and discussed. Both students and scientific staff participate in the seminar. Each student studies one research topic under the guidance of a staff member. He/she presents and discusses the topic in the seminar.

Learning Outcome
The students can formulate a research question for independent analysis in the area of integrated systems and photonics. The students can perform a literature search and organize publications by relevance. They can summarize and explain the content of the scientific publications. The students can compare the results and assess them critically. The students can present the results, discuss them and recommend further research steps on the research topic.
Reading List
• Announced and chosen depending on the research topic.

Use	Compulsory / Optional	Semester
Master, 1-Subject, Electrical and Information Engineering, (Version 2022)	Optional	1.
Master, 1-Subject, Electrical Engineering and Information Technology, (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
Seminar Nanoelectronics	etit7006-01a
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	Not graded
Duration	One Semester
Frequency	Takes place every semester
Workload per ECTS Credit	30 hours
Total Workload	150 hours
Contact Time	45
Independent Study	105
Teaching Language	English

Recommended Requirements

- Basics in Electronics
- Materials Science Lecture

Module Courses

Course Type	Course Name	Compul-sory/Optional	SWS
Seminar	Seminar Nanoelectronics	Compulsory	3

Examination(s)

Examination Name	Type of Examination	Evaluation	Compulsory / Optional	Weighting
Presentation and Paper: Seminar Nano-electronics	Other	Not graded	Compulsory	-

Further Information on the Examination(s)

The students' achievements are assessed in a composite examination.

Course Content
Seminar subjects will be announced a month before semester start on the Kiel University OLAT learning platform, typical subjects are in the fields of sensors and sensor technology, device fabrication technology, neuromorphic engineering.
Learning Outcome
The students can formulate a research question for independent analysis in the area of nanoelectronics. The students can perform a literature search and organize publications by relevance. They can summarize and explain the content of the scientific publications. The students can compare the results and assess them critically. The students can present the results, discuss them and recommend further research steps on the research topic.
Reading List
• Guidelines for the talk and the preparation of the seminar work are available on the Kiel University OLAT learning platform

Use	**Compulsory / Optional**	**Semester**
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 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
Seminar on Current Topics in Biomedical Engineering	etit7007-01a
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	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
Independent Study	105
Teaching Language	English

Module Courses			
Course Type	**Course Name**	**Compul-sory/Optional**	**SWS**
Seminar	Seminar on Current Topics in Biomedical Engineering	Compulsory	3

Examination(s)				
Examination Name	**Type of Examination**	**Evaluation**	**Compulsory / Optional**	**Weighting**
Presentation and Paper: Seminar on Current Topics in Biomedical Engineering	Other	Not graded	Compulsory	-
Further Information on the Examination(s)				
The students' achievements are assessed in a composite examination.				

Course Content
Changing current topics in biomedical engineering.

Learning Outcome
The students can formulate a research question for independent analysis in the area of biomedical engineering. They can perform a literature search and organize publications by relevance. The students can summarize and explain the content of scientific publications. They can compare the results and assess them critically. The students can present the results, discuss them and recommend further research steps on the research topic.
Reading List
• Depends on the chosen subject, will be provided by the adviser(s).

Use	Compulsory / Optional	Semester
Master, 1-Subject, Electrical and Information Engineering, (Version 2022)	Optional	1.
Master, 1-Subject, Electrical and Information Engineering, Specialisation Medical Applications, (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 Medical Applications, (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
Seminar Information and Coding Theory	etit7004-01a
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	Not graded
Duration	One Semester
Frequency	Takes place every semester
Workload per ECTS Credit	30 hours
Total Workload	150 hours
Contact Time	45
Independent Study	105
Teaching Language	English

Module Courses			
Course Type	**Course Name**	**Compul-sory/Optional**	**SWS**
Seminar	Seminar Information and Coding Theory	Compulsory	3

Examination(s)				
Examination Name	**Type of Examination**	**Evaluation**	**Compulsory / Optional**	**Weighting**
Presentation and Paper: Seminar Information and Coding Theory	Other	Not graded	Compulsory	-

Course Content
Selected topics in information and coding theory with emphasis on wireless baseband processing, visible light communications, molecular communications, and distributed sensor systems.
Learning Outcome
The students can formulate a research question for independent analysis in the area of information and coding theory. The students can perform a literature search and organize publications by relevance. They can summarize and explain the content of the scientific publications. The students can compare the results and assess them critically. The students can present the results, discuss them and recommend further research steps on the research topic.

Reading List
• Literature hints will be given by the supervisor.

Use	Compulsory / Optional	Semester
Master, 1-Subject, Electrical and Information Engineering, (Version 2022)	Optional	1.
Master, 1-Subject, Electrical and Information Engineering, Specialisation Digital Communications, (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 Digital Communications, (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
Seminar on Selected Topics in Medical Signal Processing	etit7014-01a
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	Not graded
Duration	One Semester
Frequency	Only takes place during winter semesters
Workload per ECTS Credit	30 hours
Total Workload	150 hours
Contact Time	30
Independent Study	120
Teaching Language	English

Recommended Requirements			
Fundamentals in digital signal processing			
Module Courses			
Course Type	**Course Name**	**Compul-sory/Optional**	**SWS**
Seminar	Seminar on Selected Topics in Medical Signal Proces-sing	Compulsory	2

Examination(s)				
Examination Name	**Type of Examination**	**Evaluation**	**Compulsory / Optional**	**Weighting**
Presentation and Paper: Seminar on Selec-ted Topics in Medical Signal Processing	Other	Not graded	Compulsory	-

Course Content
Students prepare a written scientific report based on literature research. They also present their findings to the other participants in form of an oral presentation. The seminar topics are closely related to the current medical signal processing research topics of the Digital Signal Processing and System Theory group.

Learning Outcome
The students can formulate a research question for independent analysis in the area of digital signal processing. The students can perform a literature search and organize publications by relevance. They can summarize and explain the content of the scientific publications. The students can compare the results and assess them critically. The students can present the results, discuss them and recommend further research steps on the research topic.
Reading List
Initial reading list provided with seminar topic.

Use	Compulsory / Optional	Semester
Master, 1-Subject, Electrical and Information Engineering, (Version 2022)	Optional	1.
Master, 1-Subject, Electrical and Information Engineering, Specialisation Medical Applications, (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 Medical Applications, (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.
Master, 1-Subject, Electrical Engineering and Business Management, (Version 2015)	Optional	1.

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Module Name	Module Code
Seminar on Selected Topics in Speech and Audio Signal Processing	etit7013-01a
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	Not graded
Duration	On Semester
Frequency	Only takes place during winter semesters
Workload per ECTS Credit	30 hours
Total Workload	150 hours
Contact Time	30
Independent Study	120
Teaching Language	English

Recommended Requirements			
Fundamentals in digital signal processing			
Module Courses			
Course Type	**Course Name**	**Compul-sory/Optional**	**SWS**
Seminar	Seminar on Selected Topics in Speech and Audio Signal Processing	Compulsory	2

Examination(s)				
Examination Name	**Type of Examination**	**Evaluation**	**Compulsory / Optional**	**Weighting**
Presentation and Paper: Seminar on Selected Topics in Speech and Audio Signal Processing	Other	Not graded	Compulsory	-

Course Content
Students prepare a written scientific report based on literature research. They also present their findings to the other participants in form of an oral presentation. The seminar topics are closely related to the current speech and audio signal processing research topics of the Digital Signal Processing and System Theory group.

Learning Outcome
The students can formulate a research question for independent analysis in the area of digital signal processing. The students can perform a literature search and organize publications by relevance. They can summarize and explain the content of the scientific publications. The students can compare the results and assess them critically. The students can present the results, discuss them and recommend further research steps on the research topic.
Reading List
Initial reading list provided with seminar topic.

Use	Compulsory / Optional	Semester
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 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 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.
Master, 1-Subject, Electrical Engineering and Business Management, (Version 2015)	Optional	1.

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Module Name	Module Code
Seminar on Selected Topics in Systems and Control	etit7009-01a
Module Coordinator	
Prof. Dr.-Ing. habil. Thomas Meurer	
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	5
Evaluation	Not graded
Duration	One Semester
Frequency	Takes place every semester
Workload per ECTS Credit	30 hours
Total Workload	150 hours
Contact Time	30
Independent Study	120
Teaching Language	English

Recommended Requirements			
Knowledge in nonlinear and optimal control corresponding to modules etit5013-01a and etit5015-01a.			
Module Courses			
Course Type	**Course Name**	**Compul-sory/Optional**	**SWS**
Seminar	Seminar on Selected Topics in Systems and Control	Compulsory	2

Examination(s)				
Examination Name	**Type of Examination**	**Evaluation**	**Compulsory / Optional**	**Weighting**
Presentation and Paper: Seminar on Selected Topics in Systems and Control	Other	Not graded	Compulsory	-
Further Information on the Examination(s)				
The students' achievements are assessed in a composite examination.				

Course Content
In the seminar current research topics in systems and control are considered.

Learning Outcome
The students comprehend advanced control and observer design methods. They can independently review and organize existing literature. They can summarize and explain the content of the scientific publications. The students can compare the results, can design and evaluate controllers for nonlinear systems, and can assess them critically. They know presentation techniques and have developed presentation skills. The students can present the results, discuss them and recommend further research steps on the research topic.
Reading List
• Will be announced during the seminar.

Use	Compulsory / Optional	Semester
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 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 Power Electronics, Control and Communications in Energy Systems, (Version 2019)	Optional	1.
Master, 1-Subject, Electric Vehicle Propulsion and Control, (Version 2020)	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
Seminar on Selected Topics in Underwater Signal Processing	etit7015-01a
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	Not graded
Duration	One Semester
Frequency	Only takes place during summer semesters
Workload per ECTS Credit	30 hours
Total Workload	150 hours
Contact Time	30
Independent Study	120
Teaching Language	English

Recommended Requirements			
Fundamentals in digital signal processing			
Module Courses			
Course Type	**Course Name**	**Compul-sory/Optional**	**SWS**
Seminar	Seminar on Selected Topics in Underwater Signal Processing	Compulsory	2

Examination(s)				
Examination Name	**Type of Examination**	**Evaluation**	**Compulsory / Optional**	**Weighting**
Presentation and Paper: Seminar on Selected Topics in Underwater Signal Processing	Other	Not graded	Compulsory	-

Course Content
Students prepare a written scientific report based on literature research. They also present their findings to the other participants in form of an oral presentation. The seminar topics are closely related to the current underwater signal processing research topics of the Digital Signal Processing and System Theory group.

Learning Outcome
The students can formulate a research question for independent analysis in the area of digital signal processing. The students can perform a literature search and organize publications by relevance. They can summarize and explain the content of the scientific publications. The students can compare the results and assess them critically. The students can present the results, discuss them and recommend further research steps on the research topic.
Reading List
Initial reading list provided with seminar topic.

Use	Compulsory / Optional	Semester
Master, 1-Subject, Electrical and Information Engineering, (Version 2022)	Optional	1.
Master, 1-Subject, Electrical and Information Engineering, Specialisation Digital Communications, (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 Digital Communications, (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.
Master, 1-Subject, Electrical Engineering and Business Management, (Version 2015)	Optional	1.

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Module Name	Module Code
Seminar Power Electronics	etit7010-01a
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	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	30
Independent Study	120
Teaching Language	English

Module Courses			
Course Type	**Course Name**	**Compul-sory/Optional**	**SWS**
Seminar	Seminar Power Electronics	Compulsory	2

Examination(s)				
Examination Name	**Type of Examination**	**Evaluation**	**Compulsory / Optional**	**Weighting**
Presentation and Paper: Seminar Power Electronics	Other	Not graded	Compulsory	-
Further Information on the Examination(s)				
The students' achievements are assessed in a composite examination.				

Course Content
The students will investigate a scientific or technical problem by means of several publications and collect, reproduce and evaluate the material in a seminar paper. Possible fields of interest are: • Power semiconductors • Power electronic circuits • Electric drives • Control of electric drives • Renewable energy production
Learning Outcome
The students can formulate a research question for independent analysis in the area of power electronics. The students can perform a literature search and organize publications by relevance. They can summarize and explain the content of the scientific publications. The students can compare the results and assess them critically. The students can present the results, discuss them and recommend further research steps on the research topic.
Reading List
• Will be given with the topic.

Use	Compulsory / Optional	Semester
Master, 1-Subject, Electrical and Information Engineering, (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 Power Electronics, Control and Communications in Energy Systems, (Version 2019)	Optional	1.
Master, 1-Subject, Electric Vehicle Propulsion and Control, (Version 2020)	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
Seminar Selected Topics in Medical Electronics	etit7012-01a
Module Coordinator	
Prof. Dr. Robert Rieger	
Organizer	
Department of Electrical and Information Engineering - Networked Electronic Systems	
Department of Electrical and Information Engineering - Sensor System Electronics	
Faculty	
Faculty of Engineering	
Examination Office	
Examination Office for Electrical Engineering and Information Technology	

ECTS Credits	5
Evaluation	Not graded
Duration	One Semester
Frequency	Takes place every semester
Workload per ECTS Credit	30 hours
Total Workload	150 hours
Contact Time	30
Independent Study	120
Teaching Language	English

Module Courses			
Course Type	**Course Name**	**Compul-sory/Optional**	**SWS**
Seminar	Seminar Selected Topics in Medical Electronics	Compulsory	2
Further Information on the Courses			
Stake in the module • Sensor System Electronics: 50 % • Networked Electronic Systems: 50 %			

Examination(s)				
Examination Name	**Type of Examination**	**Evaluation**	**Compulsory / Optional**	**Weighting**
Presentation and Paper: Seminar Selected Topics in Medical Electronics	Other	Not graded	Compulsory	-
Further Information on the Examination(s)				
The students' achievements are assessed in a composite examination.				

Course Content
Selected current topics from all fields of medical electronics.
Learning Outcome
The students can formulate a research question for independent analysis in the area of medical electronics. The students can perform a literature search and organize publications by relevance. They can summarize and explain the content of the scientific publications. The students can compare the results and assess them critically. The students can present the results, discuss them and recommend further research steps on the research topic.
Reading List
• Will be announced in the seminar based on the actual topics

Use	**Compulsory / Optional**	**Semester**
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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Module Name	Module Code
Seminar X-ray Diffraction Methods for Thin Film Analysis	etit7011-01a
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	Not graded
Duration	One Semester
Frequency	Takes place every semester
Workload per ECTS Credit	30 hours
Total Workload	150 hours
Contact Time	45
Independent Study	105
Teaching Language	English

Recommended Requirements			
Materials Science Lecture.			
Module Courses			
Course Type	**Course Name**	**Compul-sory/Optional**	**SWS**
Lecture	Seminar X-ray Diffraction Methods for Thin Film Analysis	Compulsory	1
Practical exercise	Seminar X-ray Diffraction Methods for Thin Film Analysi	Compulsory	1
Seminar	Seminar X-ray Diffraction Methods for Thin Film Analysis	Compulsory	1

Examination(s)				
Examination Name	**Type of Examination**	**Evaluation**	**Compulsory / Optional**	**Weighting**
Presentation: Seminar X-ray Diffraction Methods for Thin Film Analysis	Presentation	Not graded	Compulsory	-

Course Content

Fundamentals:

- Basics of X-Ray optics: X-Ray tubes, X-Ray detectors, monochromators, Soller slits, Göbel mirrors Elements of crystallography, Introduction to X-Ray diffraction techniques for thin film analysis

X-ray diffraction methods:

- The normal theta-two theta scan
- The phi scan
- Rocking curve (omega scan)
- Texture Measurement (Pole Figure)
- X-Ray Reflectivity
- X-ray reciprocal space mapping

Learning Outcome

The students can formulate a research question for independent analysis in the area of X-ray diffraction methods for thin film analysis. The students can perform a literature search and organize publications by relevance. They can summarize and explain the content of the scientific publications. The students can compare the results and assess them critically. The students can present the results, discuss them and recommend further research steps on the research topic.

Reading List

- B.E. Warren, X-ray Diffraction (Dover Publications Inc., New York, 1990).
- C. Hammond, The Basics of Crystallography and Diffraction (Oxford University Press, New York, 2001).
- G.S. Rohrer, Structure and Bonding in Crystalline Materials, Chapter 4, Cambridge University Press, Cambridge (2001).
- Paul F. Fewster, X-ray scattering from semiconductors, Imperial college Press, London
- Cullity, B.D., Elements of X-Ray Diffraction, Addison-Wesley, 1960.

Use	Compulsory / Optional	Semester
Master, 1-Subject, Electrical and Information Engineering, (Version 2022)	Optional	1.
Master, 1-Subject, Electrical Engineering and Information Technology, (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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Name	Code
Laboratory Courses and Projects	etit
Organizer	
Faculty	
Faculty of Engineering	
Examination Office	

Evaluation	Not graded

Use	Compulsory / Optional	Semester
Master, 1-Subject, Electrical Engineering and Information Technology, (Version 2019)	Compulsory	.

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Module Name	Module Code
M.Sc. Laboratory Advanced Control	etit8001-01a
Module Coordinator	
Prof. Dr.-Ing. habil. Thomas Meurer	
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	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	60
Independent Study	90
Teaching Language	English

Recommended Requirements

- Nonlinear Control Systems (Module etit5013-01a)

Module Courses

Course Type	Course Name	Compul-sory/Optional	SWS
Practical exercise	M.Sc. Laboratory Advanced Control	Compulsory	4

Examination(s)

Examination Name	Type of Examination	Evaluation	Compulsory / Optional	Weighting
Colloquia, Practical Tasks and Protocols: M.Sc. Laboratory Advanced Control	Other	Not graded	Compulsory	-

Course Content

Experiments addressing the themes:

- Mathematical modeling and control design using computer-algebra-systems
- Computer-assisted nonlinear control design (primary focus of laboratory)
- Implementation and experimental validation

Learning Outcome
The students have an in-depth understanding of computer-assisted modeling and control design methods for nonlinear systems. They understand the underlying mathematical and algorithmic concepts and are able to apply these to new practical problems. The students are able build and analyze simulation models. They have the ability to implement nonlinear controllers using symbolic and numerical computational tools taking into account real-time aspects.
Reading List
• T. Meurer: Nonlinear Control Systems, Lecture notes.

Use	Compulsory / Optional	Semester
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 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, Electric Vehicle Propulsion and Control, (Version 2020)	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.

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Module Name	Module Code
M.Sc. Lab Biological Information Pathways and Processing	etit8012-01a
Module Coordinator	
Prof. Dr. Hermann Kohlstedt	
Organizer	
Department of Electrical and Information Engineering - Nano Electronics	
Department of Electrical and Information Engineering - Theoretical Electrical Engineering	
Department of Electrical and Information Engineering - Bio-inspired Computation	
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	32,5 hours
Independent Study	117,5 hours
Teaching Language	English

Module Courses			
Course Type	**Course Name**	**Compul-sory/Optional**	**SWS**
Practical exercise	M.Sc. Lab Biological Information Pathways and Pro-cessing	Compulsory	6,5

Examination(s)				
Examination Name	**Type of Examination**	**Evaluation**	**Compulsory / Optional**	**Weighting**
Practical Task and Presentation: M.Sc. Lab Biological Information Pathways and Pro-cessing	Other	Not graded	Compulsory	-

Course Content

- Membrane potential and epithelial transport
- Vestibularapparat and somatosensoric
- Functionality of muscles
- Optics and acoustic: Principles of senses
- Basics of electroenzephalography (EEG)
- Information processing of the reflexsystem

Learning Outcome

The students canm describe the historical developoment of brain research and explain basal information pathways in nervous systems. They are able to verify and explain basic neuron models. They can explain neuronal mixed-signal circuits. Students are capable of describing the function of memristive devices and related neuromorphic circuits.

Reading List

- In Search of Memory, Eric R. Kandel, W. W. Norton & Company, New York 2006.
- Der Beobachter im Gehirn, Wolf Singer, Suhrkamp Verlag, Frankfurt 2002.
- Bewusst oder Unbewusst?, Heinz Georg Schuster, Wiley-VCH, Weinheim 2007.
- Analog VLSI: Circuits and Principles, ed. by Liu et al., The MIT Press 2002.
- Physics of Semiconductor Devices, S. M. Sze and Kwok K. NG, Wiley-Interscience, 2006.
- Modeling Brain Function, Daniel J. Amit, Cambridge University Press 1989.
- Neural Networks for Signal Processing, Bart Kosko, Prentice Hall Inc., Englewood Cliffs, NJ 07632, 1992
- Resistive Switching: From Fundamentals of Nanoionic Redox Processes to Memristive Device Applications Ielmini, Daniele / Waser, Rainer (Editor), Wiley-VCH, Weinheim (2016)

Use	Compulsory / Optional	Semester
Master, 1-Subject, Electrical and Information Engineering, (Version 2022)	Optional	1.
Master, 1-Subject, Electrical Engineering and Information Technology, (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
M.Sc. Laboratory Communications	etit8002-01a
Module Coordinator	
Prof. Dr.-Ing. Stephan Pachnicke	
Organizer	
Department of Electrical and Information Engineering - Communications	
Department of Electrical and Information Engineering - Digital Signal Processing and System Theory	
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	Not graded
Duration	One Semester
Frequency	Only takes place during summer semesters
Workload per ECTS Credit	30 hours
Total Workload	150 hours
Contact Time	60
Independent Study	90
Teaching Language	English

Recommended Requirements			
Knowledge of basics obtained during bachelor’s course.			
Module Courses			
Course Type	**Course Name**	**Compul-sory/Optional**	**SWS**
Practical exercise	M.Sc. Laboratory Communications	Compulsory	4

Examination(s)				
Examination Name	**Type of Examination**	**Evaluation**	**Compulsory / Optional**	**Weighting**
Colloquia and Practical Tasks: M.Sc. Laboratory Communications	Other	Not graded	Compulsory	-

Course Content
Hands-on experiments and computer simulations (MATLAB) on selected topics in communications and related fields: 1. Introduction to MATLAB 2. LTI-Systems: State Equations and Simulation 3. PAM/PCM 4. Optical/Digital Modulation 5. Erbium-doped fiber amplifier (EDFA) 6. Equalization 7. Correlation, Coherence and Information Flow 8. Signal Sources and Spectrum Analysis 9. Source Coding: Data Compression Using the Huffman and the Lempel-Ziv Algorithm 10 Cryptology: Encryption and Authentication Using the RSA Algorithm 11 Optical Communication Basics
Learning Outcome
The students gain practical expertise with signals, systems, and analysis methods for digital communications, by means of computer-based and instrumental measurement experiments. They have gained experience with both electrical and optical systems. They know how to implement basic digital signal processing in MATLAB.
Reading List
• During the lab course, a set of references is given for each experiment. • Manuals are available for all experiments.

Use	Compulsory / Optional	Semester
Master, 1-Subject, Electrical and Information Engineering, (Version 2022)	Optional	1.
Master, 1-Subject, Electrical and Information Engineering, Specialisation Digital Communications, (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 Digital Communications, (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
M.Sc. Laboratory Digital Circuit Design	etit8009-01a
Module Coordinator	
Jun.-Prof. Dr. Andreas Bahr	
Organizer	
Department of Electrical and Information Engineering - Sensor System Electronics	
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	60
Independent Study	90
Teaching Language	English

Module Courses			
Course Type	**Course Name**	**Compul-sory/Optional**	**SWS**
Lecture	M.Sc. Laboratory Digital Circuit Design	Compulsory	1
Practical exercise	M.Sc. Laboratory Digital Circuit Design	Compulsory	3

Examination(s)				
Examination Name	**Type of Examination**	**Evaluation**	**Compulsory / Optional**	**Weighting**
Report and Presentation: M.Sc. Laboratory Digital Circuit Design	Other	Not graded	Compulsory	-
Further Information on the Examination(s)				
The students' achievements are assessed in a composite examination.				

Course Content

- Introduction into Hardware Description Languages (VHDL/Verilog).
- Fundamentals of digital circuit design: FPGAS, Integrated circuits, standard cells
- Specifications and Architectures
- Digital Design Flow
- Behavioral Simulation
- Design Implementation
- Timing Simulation

Learning Outcome

The students have an in#depth understanding of the design of digital circuits for integrated circuits and FPGA as well as the design techniques and procedures. They know the major methods of design and simulation of digital circuits for FPGA and integrated circuits. The students know how to simulate the functionality and consider e.g. timing aspects during the development phase. They can use this knowledge to create new digital designs and enhance existing digital designs for FPGA and integrated circuits.

Reading List

- Wilson, Peter Design Recipes for FPGAs, 2nd Edition, London, UK : Newnes, 2016, ISBN: 978-0-08-097129-2
- Hauck, Scott; Kaufmann, Morgan, Reconfigurable computing: the theory and practice of FPGA-based computation, Amsterdam, 2008, ISBN: 978-0-12-370522-8

Further reading material will be announced during the course based on the actual topic.

Use	Compulsory / Optional	Semester
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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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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Module Name	Module Code
M.Sc. Laboratory Information Processing	etit8003-01a
Module Coordinator	
Prof. Dr.-Ing. Peter Höher	
Organizer	
Department of Electrical and Information Engineering - Information and Coding Theory	
Department of Electrical and Information Engineering - Digital Signal Processing and System Theory	
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	Not graded
Duration	One Semester
Frequency	Only takes place during winter semesters
Workload per ECTS Credit	30 hours
Total Workload	150 hours
Contact Time	60
Independent Study	90
Teaching Language	English

Module Courses			
Course Type	**Course Name**	**Compul-sory/Optional**	**SWS**
Practical exercise	M.Sc. Laboratory Information Processing	Compulsory	4
Further Information on the Courses			
Stake in the module: • Communications: 33.33 % • Digital Signal Processing and System Theory: 33.33 % • Information Theory and Coding: 33.33 %			

Examination(s)				
Examination Name	**Type of Examination**	**Evaluation**	**Compulsory / Optional**	**Weighting**
Colloquia and Practical Tasks: M.Sc. Laboratory Information Processing	Other	Not graded	Compulsory	-

Course Content
At the beginning of the winter term, selected topics in digital communications, signal processing, and information technology will be announced. The topics are subject to vary from year to year. Teams of up to four students will select a single topic. During the entire semester, the teams will work on their topic. Typically, this involves software development. Supervision is provided. By the end of the winter semester, a team-wise presentation is given within a one-day workshop.
Learning Outcome
The students acquire the ability to do a literature search on a given scientific topic, to evaluate this literature, and to extract central points. Furthermore, the students learn to implement their topic in a high-level language (e.g., MATLAB, C/C++, or Java). Finally, the students learn to work in a team and to give a presentation. After successful completion, they can critically assess latest developments in selected topics.
Reading List
• Literature hints will be given by the supervisor. This literature is tailored to the selected topic.

Use	**Compulsory / Optional**	**Semester**
Master, 1-Subject, Electrical and Information Engineering, (Version 2022)	Optional	1.
Master, 1-Subject, Electrical and Information Engineering, Specialisation Digital Communications, (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 Digital Communications, (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
M.Sc. Laboratory Machine Learning	etit8011-01a
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	Not graded
Duration	One Semester
Frequency	Only takes place during summer semesters
Workload per ECTS Credit	30 hours
Total Workload	150 hours
Contact Time	60
Independent Study	90
Teaching Language	English

Module Courses			
Course Type	**Course Name**	**Compul-sory/Optional**	**SWS**
Practical exercise	M.Sc. Laboratory Machine Learning	Compulsory	4

Examination(s)				
Examination Name	**Type of Examination**	**Evaluation**	**Compulsory / Optional**	**Weighting**
Practical Task and Presentation: M.Sc. Laboratory Machine Learning	Other	Not graded	Compulsory	-

Course Content

At the beginning of the lab students obtain an introduction into basic machine learning concepts (database creation, feature extraction, model definition and training etc.) and how to implement them using Python. Afterwards they will obtain real-world machine learning problems or topics such as

- disease classification,
- siren detection, or
- human movement classification,

which they should solve or implement with the tools mentioned above in small teams. At the end of the lab each group should give a short presentation about their work including their problem, their solution, and the performance of their implementation

Learning Outcome
Students can design and program machine learning models. They understand the building blocks and steps required to train, evaluate, and test models. They can apply the obtained knowledge to practical problems with real-world datasets. They organize and split their work in small teams. They can critically assess an obtained solution with respect to its sufficiency for a given task.
Reading List
During the lab, a set of references is given for each lab topic.

Use	Compulsory / Optional	Semester
Master, 1-Subject, Electrical and Information Engineering, (Version 2022)	Optional	1.
Master, 1-Subject, Electrical Engineering and Information Technology, (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
M.Sc. Laboratory Microwave Technology and Electromagnetic Compatibility	etit8004-01a
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	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	60
Independent Study	90
Teaching Language	English

Recommended Requirements

- Knowledge about microwave technology and electromagnetic compatibility of a B.Sc.
- Lectures regarding radio and microwave frequencies

Module Courses

Course Type	Course Name	Compul-sory/Optional	SWS
Practical exercise	M.Sc. Laboratory Microwave Technology and Electro-magnetic Compatibility	Compulsory	4

Examination(s)

Examination Name	Type of Examination	Evaluation	Compulsory / Optional	Weighting
Colloquia, Practical Tasks and Protocols: M.Sc. Laboratory Microwave Technology and Electromagnetic Compatibility	Other	Not graded	Compulsory	-

Course Content
1. Mixer 2. Phase noise of oscillators 3. Reflectometer with rectangular waveguides 4. Microwave sensors: Permittivity measurements with transmission in free space 5. Dimensioning and matching of antennas 6. Controllable antennas 7. Propagation of waves 8. Shielding of cases 9. Transmission lines and cables (analysis, shielding) 10. Measurement of transmission line emissions
Learning Outcome
The students have an in-deep understanding about the application of electromagnetic field simulators and measurement instruments. They are able to solve given problems on microwave technology and electromagnetic compatibility. They perform related simulations and measurements. They can verify the theoretical models with measurements. They summarize the results in a report.
Reading List
• Literature is suggested within the experimental instructions.

Use	Compulsory / Optional	Semester
Master, 1-Subject, Electrical and Information Engineering, (Version 2022)	Optional	1.
Master, 1-Subject, Electrical and Information Engineering, Specialisation Medical Applications, (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 Medical Applications, (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
M.Sc. Laboratory Optoelectronics	etit8005-01a
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	5
Evaluation	Not graded
Duration	One Semester
Frequency	Takes place every semester
Workload per ECTS Credit	30 hours
Total Workload	150 hours
Contact Time	45
Independent Study	105
Teaching Language	English

Entry Requirements as Stated in the Examination Regulations
Note that you have to pass the module "Photonic Components" (etit6015-01a) or the module "B.Sc. Laboratory Micro-Nano-Optosystems" (etit-311 "Bachelorpraktikum Mikro-Nano-Optosystemtechnik") prior to registering for the M.Sc. Laboratory Optoelectronics
Recommended Requirements
• Solid state physics • Semiconductor devices

Module Courses

Course Type	Course Name	Compulsory/Optional	SWS
Practical exercise	M.Sc. Laboratory Optoelectronics	Compulsory	3

Examination(s)

Examination Name	Type of Examination	Evaluation	Compulsory / Optional	Weighting
Colloquia, Practical Tasks, Reports and Presentation: M.Sc. Laboratory Optoelectronics	Other	Not graded	Compulsory	-

Course Content
The laboratory teaches theoretical and practical knowledge in the fabrication and characterization of optoelectronic devices based on organic semiconductor materials. In the laboratory organic light emitting diodes (OLEDs) and organic photo diodes (OPDs) are fabricated and characterized. The students design the devices and perform the fabrication steps independently in small groups under staff guidance in the Kieler Nano Lab. The characterization is performed by the students in the optical laboratories of the Chair for Integrated Systems and Photonics.
Learning Outcome
The students can implement fabrication procedures in a clean-room environment. They can perform literature searches for specific design tasks. They can design an optoelectronic device and develop a new fabrication procedure. They can conduct experimental characterization procedures for optoelectronic devices and prepare experiment protocols. They can assess the results critically and present and discuss their results.
Reading List
Mandatory reading • Instructions for experiments and scientific publications. Further reading • Independent further literature search.

Use	Compulsory / Optional	Semester
Master, 1-Subject, Electrical and Information Engineering, (Version 2022)	Optional	1.
Master, 1-Subject, Electrical Engineering and Information Technology, (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
M.Sc. Laboratory Power Electronics - Renewable Energy - Drive Engineering	etit8006-01a
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	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	75
Independent Study	75
Teaching Language	English

Module Courses			
Course Type	**Course Name**	**Compulsory/Optional**	**SWS**
Practical exercise	M.Sc. Laboratory Power Electronics - Renewable Energy - Drive Engineering	Compulsory	5

Examination(s)				
Examination Name	**Type of Examination**	**Evaluation**	**Compulsory / Optional**	**Weighting**
Colloquia, Practical Tasks and Protocols: M.Sc. Laboratory Power Electronics - Renewable Energy - Drive Engineering	Other	Not graded	Compulsory	-

Course Content
Laboratory exercises for power electronics, renewable energies, and drive technologies.

Learning Outcome
The students learns abilities to measure electrical quantities in experimental evaluations and they are able to analyze these measurement results for essential power electronic, renewable energy, and drive technology systems. The students can formulate theories and apply solutions formulated by themselves to solve specific technical problems.
Reading List
• N. Mohan, T. M. Undeland e W. P. Robbins, “Power Electronics: Converters, Applications, and Design”, Wiley, 2002, 0471226939. • B. Bose, “Modern Power Electronics and A.C. Drives”, Prentice Hall, 2001, ISBN 013016743.

Use	**Compulsory / Optional**	**Semester**
Master, 1-Subject, Electrical and Information Engineering, (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 Power Electronics, Control and Communications in Energy Systems, (Version 2019)	Optional	1.
Master, 1-Subject, Electric Vehicle Propulsion and Control, (Version 2020)	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
M.Sc. Laboratory Real-time Signal Processing	etit8007-01a
Module Coordinator	
Prof. Dr.-Ing. Gerhard Schmidt	
Organizer	
Department of Electrical and Information Engineering - Digital Signal Processing and System Theory	
Department of Electrical and Information Engineering - Information and Coding Theory	
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	Not graded
Duration	One Semester
Frequency	Only takes place during summer semesters
Workload per ECTS Credit	30 hours
Total Workload	150 hours
Contact Time	60
Independent Study	90
Teaching Language	English

Recommended Requirements			
Knowledge of basics obtained during bachelor course.			
Module Courses			
Course Type	**Course Name**	**Compul-sory/Optional**	**SWS**
Practical exercise	M.Sc. Laboratory Real-time Signal Processing	Compulsory	4
Further Information on the Courses			
Stake in the module: • Communications: 33.33 % • Digital Signal Processing and System Theory: 33.33 % • Information Theory and Coding: 33.33 %			

Examination(s)				
Examination Name	**Type of Examination**	**Evaluation**	**Compulsory / Optional**	**Weighting**
Practical Task, Presentation and Paper: M.Sc. Laboratory Real-time Signal Processing	Other	Not graded	Compulsory	-
Further Information on the Examination(s)				
The students' achievements are assessed in a composite examination.				

Course Content

At the beginning of the lab students obtain an introduction into the hard- and software platform they will use during the lab. Afterwards they will obtain real-world signal processing problems or topics such as

- noise suppression for speech signals,
- equalization of loudspeakers,
- software-defined radio, or
- software-defined optics

which they should solve or implement with the tools mentioned above in small teams. At the end of the lab each group should give a short presentation about their platform as well as their problem and their solution.

Learning Outcome

Students can design and program "robust" signal processing structures. They understand the impacts of basic building blocks of a signal processing systems on the choice of algorithms. Students apply efficient processing structures. They organize and split their work in in small teams. Students compare different statistical optimization approaches.

Reading List

During the seminar, a set of references is given for each lab topic.

Use	Compulsory / Optional	Semester
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 Digital Communications, (Version 2022)	Optional	1.
Master, 1-Subject, Electrical and Information Engineering, Specialisation Medical Applications, (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 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 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
M.Sc. Project Power Electronics, Control and Communications in Energy Systems	etit8010-01a
Module Coordinator	
Prof. Dr.-Ing. Marco Liserre	
Organizer	
Department of Electrical and Information Engineering - Power Electronics	
Department of Electrical and Information Engineering - Automatic Control	
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	10
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	150
Independent Study	150
Teaching Language	English

Module Courses			
Course Type	**Course Name**	**Compul-sory/Optional**	**SWS**
Project	M.Sc. Project Power Electronics, Control and Communications in Energy Systems	Compulsory	10
Further Information on the Courses			
Stake in the module: • Automatic Control: 33.33 % • Information and Coding Theory: 33.33 % • Power Electronics: 33.33 %			

Examination(s)				
Examination Name	**Type of Examination**	**Evaluation**	**Compulsory / Optional**	**Weighting**
Report and Presentation: M.Sc. Project Power Electronics, Control and Communications in Energy Systems	Other	Not graded	Compulsory	-

Course Content
Project Based Learning involving a Seminar and a Laboratory part of at least two of the following areas: • Power Electronics • Control • Communications
Learning Outcome
The student learns the ability to approach a multidisciplinary topic and to do teamwork in order to solve the given task. The students can re-elaborate the approached topic and present it through a report and a presentation on the subject.
Reading List
• Topic dependent and it will provided at the beginning of the project.

Use	**Compulsory / Optional**	**Semester**
Master, 1-Subject, Electrical and Information Engineering, (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 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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