M.Sc. Electrical Engineering and Information Technology (PO 2014)

Integrated Micro and Nano Technologies
Date: 01.03.2019

TECHNISCHE UNIVERSITÄT DARMSTADT

Department of Electrical Engineering and Information Technology

Module manual: M.Sc. Electrical Engineering and Information Technology (PO 2014)
Integrated Micro and Nano Technologies
Date: 01.03.2019

Department of Electrical Engineering and Information Technology
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Contents

1 Fundamentals

Module name Advanced Digital Integrated Circuit Design					
Module Nr. 18-ho-2010	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 120 h	**Duration** 1	**Cycle offered** SoSe
Language English			**Module owner** Prof. Dr.-Ing. Klaus Hofmann		

1	**Content** MOS Transistor Models, CMOS Logic Gates, Chip Layout and Design Rules, Static and Dynamic Behavior of CMOS Circuits, Synchonous CMOS Circuits, Performance and Power Characterisation, Design Techniques and CAD Tools, FPGA and Gate Array Technologies, Memory Technologies, Chip Test.
2	**Learning objectives / Learning Outcomes** A student is, after successful completion of this module, able to • understand the short-channel effects of modern CMOS transistors, • derive and analyse the most important circuit concepts for digital logic gates, • understand the design flow of digital ASICs based on standard cells (design, layout, simulation/verification), • knows the pros and cons of synchronous vs. asynchronous logic, multiclockphase systems, • understands the differential design methods of integrated circuits (ASIC, ASIP, Full-custom/Semicustom, PLA, PLD, FPGA), • understands basic circuitry of logic and arithmetic units (adders, multipliers, PLL/DLL), • knows the design principles and properties of integrated semiconductor memory (DRAM, SRAM, Flash. MRAM, FeRAM)
3	**Recommended prerequisite for participation** Lecture “Electronics”
4	**Form of examination** Module final exam: • Module exam (Technical examination, Written Examination, duration: 90 min, standard grading system)
5	**Grading** Module final exam: • Module exam (Technical examination, Written Examination, weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc Wi-ETiT, MSc iCE, MSc iST, MSc MEC, MSc EPE
7	**References** Lecture Slide Copies; John P. Uyemura: Fundamentals of MOS Digital Integrated Circuits; Neil Weste et al.: Principles of CMOS VLSI Design

Courses

Course Nr.	**Course name**		
18-ho-2010-vl	Advanced Digital Integrated Circuit Design		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Klaus Hofmann		Lecture	3

	Course Nr. 18-ho-2010-ue	**Course name** Advanced Digital Integrated Circuit Design		
	Instructor Prof. Dr.-Ing. Klaus Hofmann		**Type** Practice	**SWS** 1

Module name Ultra-Large Scale Integration Technology					
Module Nr. 18-sw-2010	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 120 h	**Duration** 1	**Cycle offered** WiSe
Language German			**Module owner** Prof. Dr. rer. nat. Udo Eugen Schwalke		

1 Content

0) Introduction
1) Basic material
2) Layer technology
3) Lithography
4) Etching techniques and cleaning
5) Doping processes
6) Metallisation
7) Structual design technology
8) Process control
9) Process integration
10) Simulation

2 Learning objectives / Learning Outcomes

- knowledge about the various process steps to manufacture advanced integrated circuits
- knowledge about the semiconductor process technologies for fabrication of advanced CMOS
- understand semiconductor technology in later career, to apply this technology
- and develop systems within the rapidly changing semiconductor industry

3 Recommended prerequisite for participation

examinations passed: Microelectronic devices - the basics, Electrical Engineering and Information Technology 1, Electrical Engineering and Information Technology 2, Laboratory ETiT 1, Laboratory ETiT 2, Mathematics 1, Mathematics 2, Introductory Physics

4 Form of examination

Module final exam:

- Module exam (Technical examination, Optional, standard grading system)

5 Grading

Module final exam:

- Module exam (Technical examination, Optional, weighting: 100 %)

6 Usability of this module

MSc ETiT

7 References

Lecture slides
Lecture notes in preparation
[1] Widmann, Mader, Friedrich: Technologie hochintegrierter Schaltungen, Springer Verlag
[2] Richard C. Jaeger: Introduction to Microelectronic Fabrication Prentice Hall, 2002 [3] S.M. Sze: VLSI Technology, McGraw-Hill

Courses

Course Nr. 18-sw-2010-vl	**Course name** Ultra-Large Scale Integration Technology		
Instructor Prof. Dr. rer. nat. Udo Eugen Schwalke		**Type** Lecture	**SWS** 3

	Course Nr.	Course name		
	18-sw-2010-ue	Ultra-Large Scale Integration Technology		
	Instructor		**Type**	**SWS**
	Prof. Dr. rer. nat. Udo Eugen Schwalke		Practice	1

Module name Optical Communications 1 – Components					
Module Nr. 18-ku-1060	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 120 h	**Duration** 1	**Cycle offered** SoSe
Language English			**Module owner** Prof. Dr.-Ing. Franko Küppers		

1	**Content** Optical telecommunication and data networks Optical transmisison systems The nature of light / wave-partical dualism Wave equation / planar wave Polarization Absorption, transmission, reflexion, refraction Connectors and splices Mirrors, HR-/AR coatings Film waveguides Fiber-optic waveguides Attenuation, modes, dispersion Fiber types Dispersion and dispersion compensation Kerr nonlinearity and self-phase modulation Optical filters Wavelength division multiplexers Magneto-optical effect / optical isolator / circulator Lasers / basics, concepts, types Erbium-doped fiber lasers / amplifiers (EDFL / EDFA) Optical semiconductor laser / amplifier (laser diode) Electro-optic modulator Other selected components and devices
2	**Learning objectives / Learning Outcomes** Students understand concepts, basics of physics, design criteria and system requirements (component specifications) of the most important passive and active components of optical communications.
3	**Recommended prerequisite for participation** ET 1-4, Physics
4	**Form of examination** Module final exam: • Module exam (Technical examination, Written Examination, duration: 90 min, standard grading system)
5	**Grading** Module final exam: • Module exam (Technical examination, Written Examination, weighting: 100 %)
6	**Usability of this module** BSc ETiT, MSc ETiT, MSc iCE
7	**References** Lecture slides Textbook (M. Cvijetic, I. B. Djordjevic: „Advanced Optical Communication Systems and Networks“)

Courses

Course Nr. 18-ku-1060-vl	**Course name** Optical Communications 1 – Components	
Instructor Prof. Dr.-Ing. Franko Küppers	**Type** Lecture	**SWS** 3

	Course Nr.	Course name		
	18-ku-1060-ue	Optical Communications 1 – Components		
	Instructor		**Type**	**SWS**
	Prof. Dr.-Ing. Franko Küppers		Practice	1

Module name Optical Communications 2 – Systems					
Module Nr. 18-ku-2070	**Credit Points** 4 CP	**Workload** 120 h	**Self study** 75 h	**Duration** 1	**Cycle offered** WiSe
Language English			**Module owner** Prof. Dr.-Ing. Franko Küppers		

1	**Content** Optical networks / structure, topology, layers System design Time division multiplexing, wavelength division multiplexing Modulation schemes for optical signals Transmission schemes Dispersion compensation and management Signal characterization, performance parameters
2	**Learning objectives / Learning Outcomes** Students understand selected, advanced concepts of optical communications systems and their respective basics of physics, design criteria, limitations, and optimization.
3	**Recommended prerequisite for participation** Optical Communications 1 – Components
4	**Form of examination** Module final exam: • Module exam (Technical examination, Written Examination, duration: 90 min, standard grading system)
5	**Grading** Module final exam: • Module exam (Technical examination, Written Examination, weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc iCE, BEd
7	**References** Lecture slides, textbook (M. Cvijetic, I. B. Djordjevic: „Advanced Optical Communication Systems and Networks“)

Courses

Course Nr. 18-ku-2070-vl	**Course name** Optical Communications 2 – Systems		
Instructor Prof. Dr.-Ing. Franko Küppers		**Type** Lecture	**SWS** 2
Course Nr. 18-ku-2070-ue	**Course name** Optical Communications 2 – Systems		
Instructor Prof. Dr.-Ing. Franko Küppers		**Type** Practice	**SWS** 1

Module name Microsystem Technology					
Module Nr. 18-sl-2040	**Credit Points** 4 CP	**Workload** 120 h	**Self study** 75 h	**Duration** 1	**Cycle offered** WiSe
Language German			**Module owner** Prof. Dr.-Ing. Helmut Schlaak		

1	**Content** Introduction and definitions to micro system technology; definitions, basic aspects of materials in micro system technology, basic principles of micro fabrication technologies, functional elements of microsystems, micro actuators, micro fluidic systems, micro sensors, integrated sensor-actuator systems, trends, economic aspects.
2	**Learning objectives / Learning Outcomes** To explain the structure, function and fabrication processes of microsystems, including micro sensors, micro actuators, micro fluidic and micro-optic components, to explain fundamentals of material properties, to calculate simple microsystems.
3	**Recommended prerequisite for participation** BSc
4	**Form of examination** Module final exam: • Module exam (Technical examination, Written Examination, duration: 90 min, standard grading system)
5	**Grading** Module final exam: • Module exam (Technical examination, Written Examination, weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc MEC, MSc WI-ETiT
7	**References** Script for lecture: Mikrosystemtechnik

Courses

	Course Nr. 18-sl-2040-vl	**Course name** Microsystem Technology		
	Instructor Prof. Dr.-Ing. Helmut Schlaak		**Type** Lecture	**SWS** 2
	Course Nr. 18-sl-2040-ue	**Course name** Microsystem Technology		
	Instructor Prof. Dr.-Ing. Helmut Schlaak		**Type** Practice	**SWS** 1

2 Optional Modules

2.1 IMNT I: Semiconductor Technologies and Nanoelectronics

Module name Electronic Sensors					
Module Nr. 18-sw-2020	**Credit Points** 3 CP	**Workload** 90 h	**Self study** 60 h	**Duration** 1	**Cycle offered** SoSe
Language German			**Module owner** Prof. Dr. rer. nat. Udo Eugen Schwalke		

1 Content

- Introduction
- Measurement of temperature
- Optical measurements
- Magnetic effects
- Piezoresistive effect
- Piezoelectric effect
- Pyroelectric effect
- Measurement of chemical quantities
- Detectors for ionising radiation

2 Learning objectives / Learning Outcomes

- Classify the different types of measurement parameters, like temperature, pressure, field, etc.,
- differentiate which type of sensor should be used to measure certain parameters,
- analyse and uderstand the architecture and functionality of different sensor types, as well as
- independently designing simple measurement arrangements and
- gain comprehensive knowledge over the structural design of integrated in difference to discrete sensors.

3 Recommended prerequisite for participation

- Electrical Measuring Techniques
- Laboratory Measuring Techniques
- Microelectronic devices - the basics
- Electrical Engineering and Information Technology 1
- Electrical Engineering and Information Technology 2
- Laboratory ETiT 1
- Laboratory ETiT 2
- Mathematics 1
- Mathematics 2
- Introductory Physics

4 Form of examination

Module final exam:

- Module exam (Technical examination, Optional, standard grading system)

5 Grading

Module final exam:

- Module exam (Technical examination, Optional, weighting: 100 %)

6	**Usability of this module** MSc ETiT, MSc MEC			
7	**References** • H. Schaumburg: Sensoren, ISBN 3-519-06125-2 • G. Schnell: Sensoren in der Automatisierungstechnik, ISBN 3-528-13370-8 • G. W. Schanz: Sensoren - Fühler der Messtechnik, ISBN 3-7785-1129-7			
Courses				
	Course Nr. 18-sw-2020-vl	**Course name** Electronic Sensors		
	Instructor Prof. Dr. rer. nat. Udo Eugen Schwalke		**Type** Lecture	**SWS** 2

Module name Advanced Topics in Micro- and Nano Electronics					
Module Nr. 18-sw-2030	**Credit Points** 4 CP	**Workload** 120 h	**Self study** 90 h	**Duration** 1	**Cycle offered** SoSe
Language German and English			**Module owner** Prof. Dr. rer. nat. Udo Eugen Schwalke		

1 Content

- Choice of an up-to-date theme complex or issue of the field of semiconductor technology
- Investigation and conditioning of the extracted material
- Orientation in a specific project using simulation techniques
- Compilation of a concept and presentation
- Preparation of a presentation in conference style
- Presentation of recitation with subsequent discussion in plenum

2 Learning objectives / Learning Outcomes

gain practice in searching relevant scientific informations in technical publications, conference articles, etc. learn, how and where to acquire information about specific scientific topics elaborate one specific topic complex into a consistent presentation
presentation of the theme with presentation slides, handouts and subsequent critical discussion with the audience
ability to condition results of research for presentations for international conferences and company- internal talks and to present them in a stilistically correct manner

3 Recommended prerequisite for participation

- Electrical Measuring Techniques
- Laboratory Measuring Techniques
- Microelectronic devices - the basics
- Electrical Engineering and Information Technology 1
- Electrical Engineering and Information Technology 2
- Laboratory ETiT 1
- Laboratory ETiT 2
- Mathematics 1
- Mathematics 2
- Introductory Physics

4 Form of examination

Module final exam:

- Module exam (Study archievments, Oral Examination, duration: 30 min, standard grading system)

5 Grading

Module final exam:

- Module exam (Study archievments, Oral Examination, weighting: 100 %)

6 Usability of this module

MSc ETiT

7 References

Courses

Course Nr. 18-sw-2030-pj	**Course name** Advanced Topics in Micro- and Nano Electronics	
Instructor Prof. Dr. rer. nat. Udo Eugen Schwalke	**Type** Project Seminar	**SWS** 2

Module name Optical Communications 3 – Seminar WDM Lab					
Module Nr. 18-ku-2080	**Credit Points** 4 CP	**Workload** 120 h	**Self study** 90 h	**Duration** 1	**Cycle offered** WiSe
Language English			**Module owner** Prof. Dr.-Ing. Franko Küppers		

1	**Content** Building blocks and design of a high-bit rate transmission system Experimental set-up Characterizing componennts and signals by taking measurements Simulation and optimization of the system Presentation
2	**Learning objectives / Learning Outcomes** Students are able to design, to simulate, to optimize, to build, and to characterize an optical transmission system.
3	**Recommended prerequisite for participation** Optical Communications 2 – Systerms
4	**Form of examination** Module final exam: • Module exam (Study archievments, Oral Examination, duration: 30 min, standard grading system)
5	**Grading** Module final exam: • Module exam (Study archievments, Oral Examination, weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc iCE
7	**References** Seminar slides, script, laboratory.

Courses

Course Nr. 18-ku-2080-se	**Course name** Optical Communications 3 – Seminar WDM Lab	
Instructor Prof. Dr.-Ing. Franko Küppers	**Type** Seminar	**SWS** 2

Module name Applied Superconductivity					
Module Nr. 18-bf-2030	**Credit Points** 3 CP	**Workload** 90 h	**Self study** 60 h	**Duration** 1	**Cycle offered** SoSe
Language German and English			**Module owner** Prof. Dr. Oliver Boine-Frankenheim		

1 Content

- Basics of electrical conductivity at DC and RF
- Kamerligh-Onnes experiment, Meissner effect
- Superconductor state diagram
- London equations, Typ I / II Superconductor
- Cooper pairs (briefly: BCS theory, GL theory)
- Flux quantization, Flux vortices
- AC superconductivity, two fluid model, RF cavities
- Cooper pair tunneling, Josephson junctions
- Metrology: SQUIDs, (quantum-) Hall effect
- Superconductor magnetization, Hysteresis, Bean‘s model
- Applications: Magnets in accelerator and medical technology, precision field and current measurements, energy engineering

2 Learning objectives / Learning Outcomes

The students obtain a phenomenological understanding of superconductivity, which enables them to apply superconductors in engineering practice. Starting from Maxwellian electrodynamics, superconductors are in introduced as perfect conductors at zero frequency. Both their DC and AC properties are discussed. Theory shall be reduced as much as possible. Quantum mechanics is not a requirement for the course, however, simplified quantum mechanical models will be introduced. The focus of the lecture is put on applications, e.g. magnet technology or precision metrology.

3 Recommended prerequisite for participation

Electrodynamics (Maxwell’s equations)

4 Form of examination

Module final exam:

- Module exam (Technical examination, Oral Examination, duration: 30 min, standard grading system)

5 Grading

Module final exam:

- Module exam (Technical examination, Oral Examination, weighting: 100 %)

6 Usability of this module

MSc ETiT, MSc WI-ETiT, MSc iCE, BSc/MSc CE

7 References

- W. Buckel, R. Kleiner: „Supraleitung Grundlagen und Anwendungen“; Wiley VCH, 7. Auflage 2013.
- R.G. Sharma; „Superconductivity, Basics and Applications to Magnets“; Springer International Publishing, 2015 (online available).
- H. Padamsee, J. Knobloch, T. Hays: „RF-Superconductivity for Accelerators“; 2nd edition; Wiley VCH Weinheim, 2011.
- P. Seidel (Ed.), „Applied Superconductivity“, Wiley VCH Weinheim, 2015.

Courses

	Course Nr.	Course name		
	18-bf-2030-vl	Applied Superconductivity		
	Instructor		**Type**	**SWS**
	Dr.-Ing. Uwe Niedermayer		Lecture	2

2.2 IMNT II: MEMS and Sensor

Module name Selected Chapters from Measuring and Sensor Technique					
Module Nr. 18-kn-2140	**Credit Points** 4 CP	**Workload** 120 h	**Self study** 90 h	**Duration** 1	**Cycle offered** WiSe
Language German			**Module owner** Prof. Dr. Mario Kupnik		

1	**Content** The module promotes the interlinking with current research contents and transferring from theoretical knowledge that already gained into practical applications of measuring and sensor technique. The module treats modeling methods and tools such as statistic design of experiments, analysis methods for error propagation and applications of sensors and sensor systems in current research questions in the form of a few similar to lecture introduction events and as an independent work of the students. In comparison to final works (thesis) only single aspects of a subject are looked deeply within the scope of the module.
2	**Learning objectives / Learning Outcomes** The students learn to apply existing knowledge from the measuring and sensor technique for the modelling or Simultation of a system, to work up the structured results and to present.
3	**Recommended prerequisite for participation** Measuring Technique, Sensor Technique, Sensor Signal Processing
4	**Form of examination** Module final exam: • Module exam (Study archievments, Optional, standard grading system)
5	**Grading** Module final exam: • Module exam (Study archievments, Optional, weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc Wi-ETiT, MSc MEC
7	**References** Slide set of lecture

Courses

Course Nr. 18-kn-2140-ps	**Course name** Selected Chapters from Measuring and Sensor Technique	
Instructor Prof. Dr. Mario Kupnik	**Type** Introductory Seminar Course	**SWS** 2

Module name Micro Actuators and Small Motors					
Module Nr. 18-sl-2020	**Credit Points** 4 CP	**Workload** 120 h	**Self study** 75 h	**Duration** 1	**Cycle offered** WiSe
Language German			**Module owner** Prof. Dr.-Ing. Helmut Schlaak		

1	**Content** Linear and rotating movements, action of force, actuators with mechanical and electronic commutation as well as alternating stator field, switched reluctance, stepping motors, micro actuators, piezoelectric motors and special actuators, gears. Measurement and control in actuation systems, choosing electrical actuators.
2	**Learning objectives / Learning Outcomes** The educational objective of the course is to teach the students to independently design an actuation system in precision engineering. The students will be able to describe several actuator concepts and basic physical principles and optimally choose an actuator for a specific task.
3	**Recommended prerequisite for participation** BSc ETiT
4	**Form of examination** Module final exam: • Module exam (Technical examination, Oral Examination, duration: 30 min, standard grading system)
5	**Grading** Module final exam: • Module exam (Technical examination, Oral Examination, weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc MEC, MSc WI-ETiT
7	**References** Script for lecture: Small electromechanical actuators and motors

Courses

	Course Nr. 18-sl-2020-vl	**Course name** Micro Actuators and Small Motors		
	Instructor Prof. Dr.-Ing. Helmut Schlaak		**Type** Lecture	**SWS** 2
	Course Nr. 18-sl-2020-ue	**Course name** Micro Actuators and Small Motors		
	Instructor Prof. Dr.-Ing. Helmut Schlaak		**Type** Practice	**SWS** 1

Module name Sensor Signal Processing					
Module Nr. 18-kn-2130	**Credit Points** 3 CP	**Workload** 90 h	**Self study** 60 h	**Duration** 1	**Cycle offered** Every 2. Sem.
Language German			**Module owner** Prof. Dr. Mario Kupnik		

1	**Content** The module provides knowledge in-depth about the measuring and processing of sensor signals. In the area of primary electronics, some particular characteristics such as errors, noise and intrinsic compensation of bridges and amplifier circuits (carrier frequency amplifiers, chopper amplifiers, Low-drift amplifiers) in terms of error and energy aspects are discussed. Within the scope of the secondary electronic, the classical and optimal filter circuits, modern AD conversion principles and the issues of redundancy and error compensation will be discussed.
2	**Learning objectives / Learning Outcomes** The Students acquire advanced knowledge on the structure of modern sensors and sensor proximity signal processing. They are able to select appropriate basic structure of modern primary and secondary electronics and to consider the error characteristics and other application requirements.
3	**Recommended prerequisite for participation** Measuring Technique, Sensor Technique, Electronic, Digital Signal Processing
4	**Form of examination** Module final exam: • Module exam (Technical examination, Written Examination, duration: 90 min, standard grading system)
5	**Grading** Module final exam: • Module exam (Technical examination, Written Examination, weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc Wi-ETiT, MSc MEC
7	**References** • Slide set of lecture • Skript of lecture • Textbook Tränkler „Sensortechnik“, Springer • Textbook Tietze/Schenk „Halbleiterschaltungstechnik“, Springer

Courses

Course Nr. 18-kn-2130-vl	**Course name** Sensor Signal Processing	
Instructor Prof. Dr. Mario Kupnik	**Type** Lecture	**SWS** 2

Module name Sensor Technique					
Module Nr. 18-kn-2120	**Credit Points** 4 CP	**Workload** 120 h	**Self study** 75 h	**Duration** 1	**Cycle offered** WiSe
Language German			**Module owner** Prof. Dr. Mario Kupnik		

1	**Content** The module provides basic principles of different sensors and the necessary skills for proper application of sensors. In terms of measuring chain, the focus of the event is located in the forming of any generally non-electric variable in an electrically evaluable signal. Resistive, capacitive, inductive, piezoelectric, optical and magnetic measuring principles are treated in the lectures, in order to convey measuring of important values such as force, torque, pressure, acceleration, velocity, and flow. In addition to the phenomenological description of the principles and resulting technical description, it should be traced an understood the main elements of the primary and secondary electronic for each principle. In addition to the measuring principles, the errors description will be treated. Thereby in addition to static and dynamic errors also error in the signal processing and error analysis of the entire measuring chain will be discussed.
2	**Learning objectives / Learning Outcomes** The Students acquire knowledge of the different measuring methods and their advantages and disadvantages. They can understand error in data sheets and descriptions interpret in relation to the application and are thus able to select a suitable sensor for applications in electronics and information, as well process technology and to apply them correctly.
3	**Recommended prerequisite for participation** Measuring Technique
4	**Form of examination** Module final exam: • Module exam (Technical examination, Written Examination, duration: 90 min, standard grading system)
5	**Grading** Module final exam: • Module exam (Technical examination, Written Examination, weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc WI-ETiT, MSc MEC
7	**References** • Slide set of lecture • Script of lecture • Textbook Tränkler „Sensortechnik“, Springer • Exercise script

Courses

	Course Nr. 18-kn-2120-vl	**Course name** Sensor Technique		
	Instructor Prof. Dr. Mario Kupnik		**Type** Lecture	**SWS** 2
	Course Nr. 18-kn-2120-ue	**Course name** Sensor Technique		
	Instructor Prof. Dr. Mario Kupnik		**Type** Practice	**SWS** 1

Module name Technology of Microsystems Technology					
Module Nr. 18-sl-2010	**Credit Points** 4 CP	**Workload** 120 h	**Self study** 75 h	**Duration** 1	**Cycle offered** Every 2. Sem.
Language German			**Module owner** Prof. Dr.-Ing. Helmut Schlaak		

1	**Content** Provide insights into the various production and processing methods in micro- and precision engineering and the influence of these methods on the development of devices and components.
2	**Learning objectives / Learning Outcomes** To describe coating processes like powder coating, electrochemical and vacuum deposition and CVD. To explain manufacturing of glass conponents: glass production, optical components, glass fibres, glass ceramics. To describe microfabrication technologies: photolithography, etching, diffusion, silicon micromachining, LIGA. To report manufacturing of electronic assemblies/modules and surface mount technologies (SMT).
3	**Recommended prerequisite for participation** Technology of Micro and Precision Engineering (recommended)
4	**Form of examination** Module final exam: • Module exam (Technical examination, Optional, duration: 30 min, standard grading system)
5	**Grading** Module final exam: • Module exam (Technical examination, Optional, weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc MEC, MSc Wi-ETiT
7	**References** Script for lecture: Technology of Microsystem Technology

Courses

	Course Nr. 18-sl-2010-vl	**Course name** Technology of Microsystems Technology		
	Instructor Prof. Dr.-Ing. Helmut Schlaak		**Type** Lecture	**SWS** 2
	Course Nr. 18-sl-2010-ue	**Course name** Technology of Microsystems Technology		
	Instructor Prof. Dr.-Ing. Helmut Schlaak		**Type** Practice	**SWS** 1

Module name					
Terahertz Systems and Applications					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-pr-2010	4 CP	120 h	75 h	1	Every 2. Sem.
Language			**Module owner**		
English			Prof. Dr. rer. nat. Sascha Preu		

1	**Content** The lecture will give an overview of Terahertz applications, sources and detectors with the focus on semiconductor-based devices and Terahertz systems. Terahertz detection and generation will be discussed in detail for two types of highly important devices: Schottky diodes (mixers, multi-pliers and rectifiers) and photomixers (photo-diode based and photoconductive). The exercise, where performance parameters of the discussed devices will be derived for experimentally rele-vant cases, will help to deepen the under-standing. The last day will be used for a lab tour showing our measurements facilities and hands-on experiments.
2	**Learning objectives / Learning Outcomes** After attending this lecture, the student has gained basic knowledge in the fields of THz generation, detection, systems, and applications of THz radiation, with deepened knowledge in: *Working principle, spectra and limits of continuous-wave photomixers *Working principle of Schottky diode mixers/multipliers and rectifiers in the THz range *THz Applications
3	**Recommended prerequisite for participation** Recommended: Bachelor in Electrical engineering, Physics, or Material Science Helpful: Basic knowledge in semiconductor physics, High frequency 1
4	**Form of examination** Module final exam: • Module exam (Technical examination, Oral Examination, duration: 30 min, standard grading system)
5	**Grading** Module final exam: • Module exam (Technical examination, Oral Examination, weighting: 100 %)
6	**Usability of this module** MSc etit-KTS, MSc etit-IMNT, MSc etit, MSc iCE
7	**References** *Yun-Shik Lee, „Principles of Terahertz Science and Technology,“ Springer 2009, ISBN 978-0-387-09540-0 *G. Carpintero et al., “Semiconductor Terahertz Technology: Devices and Systems at Room Temperature Operation,” Wiley 2015, ISBN: 978-1-118-92042-8

Courses

Course Nr.	**Course name**		
18-pr-2010-vl	Terahertz Systems and Applications		
Instructor		**Type**	**SWS**
Prof. Dr. rer. nat. Sascha Preu		Lecture	2
Course Nr.	**Course name**		
18-pr-2010-ue	Terahertz Systems and Applications		
Instructor		**Type**	**SWS**
Prof. Dr. rer. nat. Sascha Preu		Practice	1

Module name Advanced seminar Microsystem Technology					
Module Nr. 18-sl-2050	**Credit Points** 4 CP	**Workload** 120 h	**Self study** 90 h	**Duration** 1	**Cycle offered** SoSe
Language German			**Module owner** Prof. Dr.-Ing. Helmut Schlaak		

1	**Content** Intensive arguing with current research topics in microsystem technology. The compilation of self gatherd information and a scientific report are evaluated thereby and consulted as test achievement.
2	**Learning objectives / Learning Outcomes** To explain current specialized topics in the area of the micro system technology. To work out a scientific specialized topic independently, and to give a lecture on it. To write a scientific report about this topic. Getting to know the institute's own clean room laboratory for MEMS fabrication. Autonoumous fabrication of micro structures.
3	**Recommended prerequisite for participation** Microsystem Technology
4	**Form of examination** Module final exam: • Module exam (Study archievments, Optional, standard grading system)
5	**Grading** Module final exam: • Module exam (Study archievments, Optional, weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc MEC, MSc WI-ETiT
7	**References**

Courses

Course Nr. 18-sl-2050-se	**Course name** Advanced seminar Microsystem Technology	
Instructor Prof. Dr.-Ing. Helmut Schlaak	**Type** Seminar	**SWS** 2

2.3 IMNT III: Electronic Circuits and Systems Design

Module name Circuit Building Blocks for Communication Systems					
Module Nr. 18-ho-2190	**Credit Points** 4 CP	**Workload** 120 h	**Self study** 75 h	**Duration** 1	**Cycle offered** WiSe
Language English			**Module owner** Prof. Dr.-Ing. Klaus Hofmann		

1	**Content** Methods and Algorithms for the Circuit Implementations in communication systems
2	**Learning objectives / Learning Outcomes** A student is, after successful completion of this module, able to understand 1. the essential circuit building blocks of a communication system and able to describe them on transistor level, 2. Protocols and hardware-implementations of high-speed bus-systems , 3. Clock/data recovery techniques (DLL, PLL, Timing Recovery), 4. Aspects of error-detection and – avoidance.
3	**Recommended prerequisite for participation** Lecture “Advanced Digital Integrated Circuit Design” and "Hardware Description Languages:Verilog and VHDL"
4	**Form of examination** Module final exam: • Module exam (Technical examination, Written Examination, duration: 90 min, standard grading system)
5	**Grading** Module final exam: • Module exam (Technical examination, Written Examination, weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc Wi-ETiT, MSc iCE, MSc MEC, MSc EPE
7	**References** Slide Copies

Courses

	Course Nr. 18-ho-2190-vl	**Course name** Circuit Building Blocks for Communication Systems		
	Instructor Prof. Dr.-Ing. Klaus Hofmann		**Type** Lecture	**SWS** 2
	Course Nr. 18-ho-2190-ue	**Course name** Circuit Building Blocks for Communication Systems		
	Instructor Prof. Dr.-Ing. Klaus Hofmann		**Type** Practice	**SWS** 1

Module name Digital Printing					
Module Nr. 16-17-5030	**Credit Points** 4 CP	**Workload** 120 h	**Self study** 90 h	**Duration** 1	**Cycle offered** Every 2. Sem.
Language German			**Module owner** Prof. Dr. Edgar Dörsam		

1	**Content** Terminology of digital printing; Workflow, screening, raster technology; Tonal value; Technology of digital printing (electrophotography, inkjet, thermal transfer printing); Toner, ink and print substrate; Design.
2	**Learning objectives / Learning Outcomes** On successful completion of this module, students should be able to: • Explain terms and the classification system of digital printing technology. • Estimate the fields of application (of digital printing technologies). • Describe the different principles of workflows. • Describe the meaning of the term screening and the reproduction of halftones. • Precisely explain the principles and technical details of electrophotography, thermal transfer printing, and inkjet printing. • Give a general overview of different construction principles of digital printing systems. • Rate environmental properties of digital printing systems.
3	**Recommended prerequisite for participation** None
4	**Form of examination** Module final exam: • Module exam (Technical examination, Technical Examination, standard grading system)
5	**Grading** Module final exam: • Module exam (Technical examination, Technical Examination, weighting: 100 %)
6	**Usability of this module** WPB Master MPE III (Wahlfächer aus Natur- und Ingenieurwissenschaft) WPB Master PST III (Fächer aus Natur- und Ingenieurwissenschaft für Papiertechnik) Master ETiT INMT
7	**References** The current lecture notes can be downloaded from the web pages of the institute while the semester is in session.

Courses

Course Nr. 16-17-5030-vl	**Course name** Digital Printing	
Instructor	**Type** Lecture	**SWS** 2

Module name Printed Electronics					
Module Nr. 16-17-5110	**Credit Points** 4 CP	**Workload** 120 h	**Self study** 90 h	**Duration** 1	**Cycle offered** Every 2. Sem.
Language German			**Module owner** Prof. Dr. Edgar Dörsam		

1 Content

Printing technologies for functional printing (printing methods and systems); Design and materials for printed electronics (aerial, OFET, RFID); Activities for quality assurance; Examples of application (aerial, RFID, OFET, photovoltaic, batteries, lab on a chip).

2 Learning objectives / Learning Outcomes

On successful completion of this module, students should be able to:

- Describe the printing technologies that are applicable for “Printed Electronics”.
- Name materials that are appropriate to printing processes and to describe the impact of the materials on the design e.g. of antennas and OFETs.
- Classify and rate different activites for quality assurance.
- Explain basic functions, configurations, materials, and specific properties of printed antennas, RFIDs, photovoltaics and batteries.
- Describe “Printed Electronics” as a multidisciplinary task that consists of electrical engineering, material science, and mechanical engineering.

3 Recommended prerequisite for participation

Mechanical components and Mechatronics I and II recommended

4 Form of examination

Module final exam:

- Module exam (Technical examination, Technical Examination, standard grading system)

5 Grading

Module final exam:

- Module exam (Technical examination, Technical Examination, weighting: 100 %)

6 Usability of this module

WPB Master MPE III (Wahlfächer aus Natur- und Ingenieurwissenschaft)
WPB Master PST III (Fächer aus Natur- und Ingenieurwissenschaft für Papiertechnik)
Master ETiT IMNT; Master Mechatronik

7 References

The current lecture notes can be downloaded from the web pages of the institute while the semester is in session.

Courses

Course Nr. 16-17-5110-vl	**Course name** Printed Electronics	
Instructor	**Type** Lecture	**SWS** 2

Module name					
Computer Systems II					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-hb-2030	6 CP	180 h	120 h	1	WiSe
Language			**Module owner**		
German			Prof. Dr.-Ing. Christian Hochberger		

1 Content

- Configurable Technologies
- FPGA architectures and properties
- System-On-Chip, HW components, SW toolchain, support SW
- Coarse grained reconfigurable architectures, PE architecture, Modulo schedu-ling

2 Learning objectives / Learning Outcomes

After completion of the module, students know reconfigurable technologies as well as chip architecture that employ them (e.g. FPGAs and CGRAs). They can select an ap-propriate technology for a given specific application. They know the components a system-on-chip (SoC) consists of. Students can configure and program an application specific SoC. They can map simple applications to a CGRA and know the limitations and pitfalls of this mapping.

3 Recommended prerequisite for participation

Thorough basic knowledge of digital circuits and computer achitecture. as can be ob-tained in the lectures “Logischer Entwurf” and “Rechnersysteme I”. Additionally, stu-dents should be able to write simple programs in the programming language C.

4 Form of examination

Module final exam:

- Module exam (Technical examination, Oral Examination, duration: 30 min, standard grading system)

5 Grading

Module final exam:

- Module exam (Technical examination, Oral Examination, weighting: 100 %)

6 Usability of this module

MSc ETiT, MSc iST, MSc iCE, MSc Wi-ETiT

7 References

The slides (in German) of the lecture can be obtained through moodle.

Courses

Course Nr.	Course name		
18-hb-2030-vl	Computer Systems II		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Christian Hochberger		Lecture	3
Course Nr.	**Course name**		
18-hb-2030-ue	Computer Systems II		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Christian Hochberger		Practice	1

Module name					
Computer Aided Design for SoCs					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-ho-2200	5 CP	150 h	90 h	1	SoSe
Language			**Module owner**		
English			Prof. Dr.-Ing. Klaus Hofmann		

1 Content

CAD-Concepts for the design and simulation of integrated system-on-chips

2 Learning objectives / Learning Outcomes

A student is, after successful completion of this module, able to understand

- The most important design and verification abstractions as well as the design flow for the design of integrated electronic systems,
- Selected algorithms for optimization, simulation and solving of design tasks,
- Advanced methods for the design and simulation of analog integrated circuits in modern CMOS technologies,
- Advanced concepts of hardware description languages and their concepts (Verilog, VHDL, Verilog-A, Verilog-AMS, System-Verilog)

3 Recommended prerequisite for participation

Lecture "Advanced Digital Integrated Circuit Design" (can be attended in parallel) and „Analog Integrated Circuit Design" and "Logic Design"

4 Form of examination

Module final exam:

- Module exam (Technical examination, Written Examination, duration: 90 min, standard grading system)

5 Grading

Module final exam:

- Module exam (Technical examination, Written Examination, weighting: 100 %)

6 Usability of this module

MSc ETiT, MSc iST, MSc MEC, MSc Wi-ETiT, MSc iCE

7 References

Slide Copies

Courses

Course Nr.	Course name		
18-ho-2200-vl	Computer Aided Design for SoCs		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Klaus Hofmann		Lecture	2
Course Nr.	**Course name**		
18-ho-2200-ue	Computer Aided Design for SoCs		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Klaus Hofmann		Practice	1
Course Nr.	**Course name**		
18-ho-2200-pr	Computer Aided Design for SoCs		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Klaus Hofmann		Internship	1

Module name Industrial Electronics					
Module Nr. 18-ho-2210	**Credit Points** 4 CP	**Workload** 120 h	**Self study** 75 h	**Duration** 1	**Cycle offered** WiSe
Language German and English			**Module owner** Prof. Dr.-Ing. Klaus Hofmann		

1	**Content** Typical Struture of Industrial Electronics Components. Characteristics of Typical Building Blocks (Digital Core, Sensor Frontend, Actuator Frontend, Supply and Reference Level), Functioning of Relevant Field Bus Systems, Knowledge of Relevant Standards and Technical Regulations.
2	**Learning objectives / Learning Outcomes** After successfull completion of the module, students are able to: 1. understand the use of electronic components in typical industrial environments, 2. understand the function of the building blocks of typical IE comonents, 3. deeply understand the functioning of analog bulding blocks, 4. understand relevant field bus systemes, 5. understand the regulatory and technical standards of industrial electronics components.
3	**Recommended prerequisite for participation** Lecture “Elektronik“ and “Analog IC Design”
4	**Form of examination** Module final exam: • Module exam (Technical examination, Optional, standard grading system)
5	**Grading** Module final exam: • Module exam (Technical examination, Optional, weighting: 100 %)
6	**Usability of this module** MSc ETiT, M.Sc. iCE, M.Sc. MEC
7	**References** • Dietmar Schmid, Gregor Häberle, Bernd Schiemann, Werner Philipp, Bernhard Grimm, Günther Buchholz, Jörg Oestreich, Oliver Gomber, Albrecht Schilling: „Fachkunde Industrieelektronik und Informationstechnik“; Verlag Europa-Lehrmittel, 11 th Ed. 2013. • Gunter Wellenreuther, Dieter Zastrow; „Automatisieren mit SPS – Theorie und Praxis“; Springer Verlag, 6 th Ed. 2015. • Ulrich Tietze, Christoph Schenk, Eberhard Gamm: „Halbleiter-Schaltungstechnik“; Springer Verlag, 15 th Ed. 2016.

Courses

Course Nr. 18-ho-2210-vl	**Course name**		
Instructor Dr.-Ing. Roland Steck		**Type** Lecture	**SWS** 2
Course Nr. 18-ho-2210-ue	**Course name**		
Instructor Dr.-Ing. Roland Steck		**Type** Practice	**SWS** 1

2.4 IMNT IV: (Project-)seminar

Module name Project Seminar Design for Testability					
Module Nr. 18-ho-2130	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 135 h	**Duration** 1	**Cycle offered** SoSe
Language English			**Module owner** Prof. Dr.-Ing. Klaus Hofmann		
1	**Content** Learning advanced Methods for Testing Microchips after Manufacturing and Practical Application in small Design Scenarios, Final Presentation				
2	**Learning objectives / Learning Outcomes** Learning advanced Methods for Testing Microchips after Manufacturing and Practical Application in small Design Scenarios, Final Presentation				
3	**Recommended prerequisite for participation** Lecture “Advanced Digital Integrated Circuit Design”				
4	**Form of examination** Module final exam: • Module exam (Study archievments, Optional, standard grading system)				
5	**Grading** Module final exam: • Module exam (Study archievments, Optional, weighting: 100 %)				
6	**Usability of this module** MSc ETiT, MSc Wi-ETiT, MSc iCE, MSc iST, MSc MEC, MSc EPE				
7	**References** Slide Copies				
Courses					
	Course Nr. 18-ho-2130-pj	**Course name** Project Seminar Design for Testability			
	Instructor Prof. Dr.-Ing. Klaus Hofmann			**Type** Project Seminar	**SWS** 3

Module name Project Seminar Electromagnetic CAD					
Module Nr. 18-dg-1060	**Credit Points** 8 CP	**Workload** 240 h	**Self study** 180 h	**Duration** 1	**Cycle offered** WiSe/SoSe
Language German and English			**Module owner** Prof. Dr.-Ing. Herbert De Gersem		

1	**Content** Work on a more complex project in numerical field calculation using commercial tools or own software.
2	**Learning objectives / Learning Outcomes** Students will be able to simulate complex engineering problems with numerical field simulation software. They are able to estimate modelling and numerical errors. They know how to present the results on a scientific level in talks and a paper. Students are able to organize teamwork.
3	**Recommended prerequisite for participation** Good understanding of electromagnetic fields, knowledge about numerical simulation methods.
4	**Form of examination** Module final exam: • Module exam (Study archievments, Oral Examination, duration: 20 min, standard grading system)
5	**Grading** Module final exam: • Module exam (Study archievments, Oral Examination, weighting: 100 %)
6	**Usability of this module** MSc ETiT
7	**References** Course notes “Computational Electromagnetics and Applications I-III”, further material is provided.

Courses

Course Nr.	**Course name**		
18-dg-1060-pj	Project Seminar Electromagnetic CAD		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Herbert De Gersem		Project Seminar	4

Module name					
Seminar Integrated Electronic Systems Design A					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-ho-2160	4 CP	120 h	90 h	1	WiSe/SoSe
Language			**Module owner**		
English			Prof. Dr.-Ing. Klaus Hofmann		

1	**Content** Research oriented Formulation of a Topic within the area of Microelectronics System Design; Creation of a written Documentation and Presentation; Team Work
2	**Learning objectives / Learning Outcomes** A student is, after successful completion of this module, able to 1. gain a deep understanding of the chosen research subject in the field of integrated electronic systems, 2. write an essay on the chosen subject in a comprehesive form and present the outcome to an audience
3	**Recommended prerequisite for participation** Advanced Digital Integrated Circuit Design, CAD Methods, Computer Architectures, Programming Know-How
4	**Form of examination** Module final exam: • Module exam (Study archievments, Oral Examination, duration: 45 min, standard grading system)
5	**Grading** Module final exam: • Module exam (Study archievments, Oral Examination, weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc Wi-ETiT, MSc iCE, MSc iST, MSc MEC
7	**References** Topic-oriented Materials will be provided

Courses

Course Nr.	Course name		
18-ho-2160-se	Seminar Integrated Electronic Systems Design A		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Klaus Hofmann		Seminar	2

2.5 IMNT V: Practical courses

Module name Advanced Integrated Circuit Design Lab					
Module Nr. 18-ho-2120	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 135 h	**Duration** 1	**Cycle offered** SoSe
Language English			**Module owner** Prof. Dr.-Ing. Klaus Hofmann		

1	**Content** Practical Design Tasks in Full Custom Design of Digital or Analog Ciruits using State-of-the-Art Commercial CAD Tools
2	**Learning objectives / Learning Outcomes** A student is, after successful completion of this module, able to 1. develop and verify transistor circuitry using Cadence 2. simulate logic and analog circuits (Pre- and Postlayout) 3. draw, verify and extract layout
3	**Recommended prerequisite for participation** Lecture “Advanced Digital Integrated Circuit Design” or “Analog Integrated Circuit Design”
4	**Form of examination** Module final exam: • Module exam (Study archievments, Optional, standard grading system)
5	**Grading** Module final exam: • Module exam (Study archievments, Optional, weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc Wi-ETiT, MSc iCE, MSc iST, MSc MEC, MSc EPE
7	**References** ADIC Lecture Slide Copies; John P. Uyemura: Fundamentals of MOS Digital Integrated Circuits; Neil Weste et al.: Principles of CMOS VLSI Design

Courses

Course Nr. 18-ho-2120-pr	**Course name** Advanced Integrated Circuit Design Lab		
Instructor Prof. Dr.-Ing. Klaus Hofmann		**Type** Internship	**SWS** 3

Module name Mechatronics Workshop					
Module Nr. 18-bi-1050	**Credit Points** 2 CP	**Workload** 60 h	**Self study** 45 h	**Duration** 1	**Cycle offered** WiSe
Language German			**Module owner** Prof. Dr. techn. Dr.h.c. Andreas Binder		

1	**Content** During the mechatronic workshop students get the possibility to design and construct their own fixture, which contains a ball track and a ball elevator mechanism. Herefore dimensional plans have to be understood correctly. Afterwards all components (i.e. circuit board, rails and holders) have to be designed and manufactured within the electronic lab and the workshop, where students work independently with turning, drilling and milling machines. The mechatronic workshop allows students to gain practical experience and knowledge in contruction, assembling and PCB layout design.
2	**Learning objectives / Learning Outcomes** Understanding of construction plans, circuit layout design, practical experience with turning, drilling and milling machines.
3	**Recommended prerequisite for participation** You have to bring your **own printed** copy of the script. This is mandatory for attending the course. The script will be published on the moodle platform.
4	**Form of examination** Module final exam: • Module exam (Study archievments, Optional, standard grading system)
5	**Grading** Module final exam: • Module exam (Study archievments, Optional, weighting: 100 %)
6	**Usability of this module** BSc/MSc ETiT, BSc/MSc MEC
7	**References** • Lecture Notes „Mechatronics Workshop“ • J. Dillinger et al.: Fachkunde Metall, Europa-Lehrmittel, 2007 • U. Tietze, C. Schenk, E. Gamm: Halbleiter-Schaltungstechnik, Springer, 2012

Courses

Course Nr. 18-bi-1050-pr	**Course name** Mechatronics Workshop	
Instructor Prof. Dr. techn. Dr.h.c. Andreas Binder	**Type** Internship	**SWS** 1