TECHNISCHE HOCHSCHULE LÜBECK

Module: Radio Frequencies

Level	Bachelor	**Short Name**	
Responsible Lecturers	Bartels – v. Mensenkampff, Stefan, Prof. Dr. – Ing.		
Department, Facility	Electrical Engineering and Computer Science		
Course of Studies	Elektrotechnik - Energiesysteme und Automation, Bachelor		
Compulsory/elective	Compulsory	**ECTS Credit Points**	5
Semester of Studies	5	**Semester Hours per Week**	4
Length (semesters)	1	**Workload (hours)**	150
Frequency	WiSe	**Presence Hours**	60
Teaching Language	English	**Self-Study Hours**	90

The following section is filled only if there is **exactly one** module-concluding exam.

Exam Type	Written Exam	**Exam Language**	English
Exam Length (minutes)	120	**Exam Grading System**	One-third Grades
Learning Outcomes	The Students are familiar with analog modulation techniques and their applications. They can handle noise-, bandwidth- and nonlinearity-related problems. They can determine and optimize system`s performance. They can design circuits to realize basic RF-components. They can design and analyze RF-Receiver-systems. The students can handle RF-measurement equipment. They can document experiments. The students can give technical presentations.		
Participation Prerequisites	Analog Electronics, Signals and Systems		

The previous section is filled only if there is **exactly one** module-concluding exam.

Consideration of Gender and Diversity Issues	✔ Use of gender-neutral language (THL standard) ✔ Target group specific adjustment of didactic methods ✔ Making subject diversity visible (female researchers, cultures etc.)
Applicability	Microwaves, Communications
Remarks	

TECHNISCHE HOCHSCHULE LÜBECK

Module Course: Radio Frequencies (Lecture)

(of Module: Radio Frequencies)

Course Type	Lecture	**Form of Learning**	Presence
Mandatory Attendance	no	**ECTS Credit Points**	3
Participation Limit		**Semester Hours per Week**	3
Group Size		**Workload (hours)**	90
Teaching Language	English	**Presence Hours**	45
Study Achievements ("Studienleistung", SL)		**Self-Study Hours**	45
SL Length (minutes)		**SL Grading System**	

The following section is filled only if there is a course-specific exam.

Exam Type		**Exam Language**	
Exam Length (minutes)		**Exam Grading System**	
Learning Outcomes			
Participation Prerequisites			

The previous section is filled only if there is a course-specific exam.

Contents

1. Introduction

2. Noise
   - Thermal Noise
   - Noise by complex Impedances
   - Signal to Noise Ratio SNR
   - Noise Sources in Semiconductors
   - Noise Figure, Noise Ratio
   - Noise Ratio of passive Components
   - System`s Noise Ratio, Friis Formula

3. Nonlinearities
   - Taylor Series Representation
   - Output Spectrum
   - 3rd Order Intercept Point IP3

4. Transistor`s Giacoletto Model
   - Giacoletto Model of Bipolar Transistor
   - Small-Signal Model of FET
   - Influence of Model Elements on RF Performance
     - Source-Impedance
     - Miller-Effect
   - Cascode/Dual Gate FET

5. Superheterodyne Receivers
   - Up- and Down-Conversion
   - Mixer Concepts

	• Image-Reject Mixer
	• Homodyne Receiver
	
	6. Oscillators
	• One Port Oscillators
	• Two Port Oscillators
	• Oscillator`s Phase Noise
	• Crystal Oscillator
	• VCO
	
	7. Modulation
	• Amplitude Modulation AM
	  • General
	  • Realization
	  • AM De-Modulation
	• Frequency Modulation FM
	  • General
	  • Phase and Frequency Modulation
	  • Realization
	  • FM De-Modulation
	• Phase-Shift Keying PSK
	• Quadrature Amplitude Modulation QAM
	• De-Modulator`s Noise Performance
	• Sensitivity
	
	8. Transmission Lines
	• Distributed Circuit Model
	• Wave Propagation on Transmission Lines
	• Reflection Coefficient
	• Phase Velocity
	• Standing Waves

Literature	• Worksheets from lecture (online) • Young, Electronic Communication Techniques, Prentice Hall 2003 • Pozar, David M. Microwave Engineering, Wiley and Sons Inc., 2005. • Meinke, Gundlach, Taschenbuch der Hochfrequenztechnik, Springer 2009 • Mäusl, R., Analoge und digitale Modulationsverfahren, Hüthig 2004 • Voges, E., Hochfrequenztechnik I, Verlag Moderne Industrie 2003
Remarks	

Module Course: Radio Frequencies (Laboratory)

(of Module: Radio Frequencies)

Course Type	Practical Training	**Form of Learning**	Presence
Mandatory Attendance	yes	**ECTS Credit Points**	2
Participation Limit		**Semester Hours per Week**	1
Group Size	12	**Workload (hours)**	60
Teaching Language	English	**Presence Hours**	15
Study Achievements ("Studienleistung", SL)	Practical Training	**Self-Study Hours**	45
SL Length (minutes)		**SL Grading System**	Pass

The following section is filled only if there is a course-specific exam.

Exam Type		**Exam Language**	
Exam Length (minutes)		**Exam Grading System**	
Learning Outcomes			
Participation Prerequisites			

The previous section is filled only if there is a course-specific exam.

Contents	• AM/FM Spectrum Analysis • QAM • RF-Receiver • Presentation Topics to be determined individually
Literature	• Worksheets from lecture (online) and Labscripts (online) • Young, Electronic Communication Techniques, Prentice Hall 2003 • Pozar, David M. Microwave Engineering, Wiley and Sons Inc., 2005.
Remarks	