

**Module: Radio Frequencies**

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

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

<b>Exam Type</b>	Written Exam	<b>Exam Language</b>	English
<b>Exam Length (minutes)</b>	120	<b>Exam Grading System</b>	One-third Grades
<b>Learning Outcomes</b>	<p>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.</p> <p>They can design circuits to realize basic RF-components. They can design and analyze RF-Receiver-systems.</p> <p>The students can handle RF-measurement equipment.</p> <p>They can document experiments.</p> <p>The students can give technical presentations.</p>		
<b>Participation Prerequisites</b>	Analog Electronics, Signals and Systems		

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

<b>Consideration of Gender and Diversity Issues</b>	<ul style="list-style-type: none"> <li>✓ Use of gender-neutral language (THL standard)</li> <li>✓ Target group specific adjustment of didactic methods</li> <li>✓ Making subject diversity visible (female researchers, cultures etc.)</li> </ul>
<b>Applicability</b>	Microwaves, Communications
<b>Remarks</b>	

## Module Course: Radio Frequencies (Lecture)

(of Module: Radio Frequencies)

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

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

<b>Exam Type</b>		<b>Exam Language</b>	
<b>Exam Length (minutes)</b>		<b>Exam Grading System</b>	
<b>Learning Outcomes</b>			
<b>Participation Prerequisites</b>			

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

<b>Contents</b>	<ol style="list-style-type: none"> <li>1. Introduction</li> <li>2. Noise <ul style="list-style-type: none"> <li>• Thermal Noise</li> <li>• Noise by complex Impedances</li> <li>• Signal to Noise Ratio SNR</li> <li>• Noise Sources in Semiconductors</li> <li>• Noise Figure, Noise Ratio</li> <li>• Noise Ratio of passive Components</li> <li>• System`s Noise Ratio, Friis Formula</li> </ul> </li> <li>3. Nonlinearities <ul style="list-style-type: none"> <li>• Taylor Series Representation</li> <li>• Output Spectrum</li> <li>• 3rd Order Intercept Point IP3</li> </ul> </li> <li>4. Transistor`s Giacoletto Model <ul style="list-style-type: none"> <li>• Giacoletto Model of Bipolar Transistor</li> <li>• Small-Signal Model of FET</li> <li>• Influence of Model Elements on RF Performance <ul style="list-style-type: none"> <li>• Source-Impedance</li> <li>• Miller-Effect</li> </ul> </li> <li>• Cascode/Dual Gate FET</li> </ul> </li> <li>5. Superheterodyne Receivers <ul style="list-style-type: none"> <li>• Up- and Down-Conversion</li> <li>• Mixer Concepts</li> </ul> </li> </ol>
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- 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)

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

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

<b>Exam Type</b>		<b>Exam Language</b>	
<b>Exam Length (minutes)</b>		<b>Exam Grading System</b>	
<b>Learning Outcomes</b>			
<b>Participation Prerequisites</b>			

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

<b>Contents</b>	<ul style="list-style-type: none"> <li>• AM/FM Spectrum Analysis</li> <li>• QAM</li> <li>• RF-Receiver</li> <li>• Presentation Topics to be determined individually</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Worksheets from lecture (online) and Labscripts (online)</li> <li>• Young, Electronic Communication Techniques, Prentice Hall 2003</li> <li>• Pozar, David M. Microwave Engineering, Wiley and Sons Inc., 2005.</li> </ul>
<b>Remarks</b>	