Curriculum for the Master’s Programme in Wireless Communication Systems

Aalborg University
September 2018
Preface:
Pursuant to Act 261 of March 18, 2015 on Universities (the University Act) with subsequent changes, the following curriculum for the Master's programme in the Master's programme in Wireless Communication Systems is stipulated. The programme also follows the Joint Programme Regulations and the Examination Policies and Procedures for The Technical Faculty of IT and Design.
Table of Contents

Table of Contents ......................................................................................................................... 2
Chapter 1: Legal Basis of the Curriculum, etc. .................................................................................... 3
  1.1 Basis in ministerial orders ...................................................................................................... 3
  1.2 Faculty affiliation ................................................................................................................... 3
  1.3 Board of Studies affiliation .................................................................................................... 3
  1.4 External Examiners Corps ..................................................................................................... 3
Chapter 2: Admission, Degree Designation, Programme Duration ..................................................... 3
  2.1 Admission .............................................................................................................................. 3
  2.2 Degree designation in Danish and English ............................................................................ 3
  2.3 The programme’s specification in ECTS credits ................................................................... 4
  2.4 Competence profile on the diploma ....................................................................................... 4
Chapter 3: Content and Organization of the Programme ..................................................................... 5
  Descriptions of modules............................................................................................................... 7
  1st Semester ................................................................................................................................ 7
  2nd Semester ............................................................................................................................... 11
  3rd Semester ................................................................................................................................ 16
  4th Semester ................................................................................................................................ 22
Chapter 4: Entry into Force, Interim Provisions and Revision .......................................................... 24
  5.1 Rules concerning written work, including the Master’s thesis ............................................ 24
  5.2 Rules concerning credit transfer (merit), including the possibility for choice of modules that are part of another programme at a university in Denmark or abroad ........................................ 24
  5.3 Rules for examinations ......................................................................................................... 24
  5.4 Exemption ............................................................................................................................ 25
  5.5 Rules and requirements for the reading of texts .................................................................. 25
  5.6 Additional information ......................................................................................................... 25

5
Chapter 1: Legal Basis of the Curriculum, etc.

1.1 Basis in ministerial orders
The Master’s programme in Wireless Communication Systems is organised in accordance with the Ministry of Higher Education and Science’s Order no. 1328 of November 15, 2016 on Bachelor’s and Master’s Programmes at Universities (the Ministerial Order of the Study Programmes) and Ministerial Order no. 1062 of June 30, 2016 on University Examinations (the Examination Order). Further reference is made to Ministerial Order no. 111 of January 30, 2017 (the Admission Order) and Ministerial Order no. 114 of February 3, 2015 (the Grading Scale Order) with subsequent changes.

1.2 Faculty affiliation
The Master’s programme falls under the Technical Faculty of IT and Design, Aalborg University.

1.3 Board of Studies affiliation
The Master’s programme falls under the Board of Studies for Electronics and IT.

1.4 External Examiners Corps
The Master’s programme is associated with the external examiners for engineering educations: electro (In Danish: Censorkorps for Ingeniøruddannelsenernes landsdækkende censorkorps; elektro).

Chapter 2: Admission, Degree Designation, Programme Duration and Competence Profile

2.1 Admission
Applicants with a legal claim to admission (retnskrav):
Applicants with one of the following degrees are entitled to admission:

- Bachelor of Science in Engineering (Electronic Engineering and IT with specialisation in Communication Systems), Aalborg University
- Bachelor of Science in Engineering (Internet Technologies and computer Engineering with specialisation in Communication Systems), Aalborg University

Applicants without legal claim to admission:
Bachelor’s programmes qualifying students for admission:

- Bachelor of Science (BSc) in Engineering (Electronic Engineering and IT with specialisation in Signal Processing) (AAU)
- Bachelor of Science in Engineering (Electronic Engineering and IT with specialisation in Control Engineering), Aalborg University (AAU)
- Bachelor of Science (BSc) in Engineering (Electronic Engineering and IT with specialisation in Informatics) (AAU)
- Bachelor of Science (BSc) in Engineering (Internet Technologies and Computer Engineering with specialization in Signal Processing) (AAU)
- Bachelor of Science (BSc) in Engineering (Internet Technologies and computer Engineering with specialisation in Control Engineering), Aalborg University (AAU)
- Bachelor of Science (BSc) in Engineering (Internet Technologies and Computer Engineering with specialization in Informatics) (AAU)

2.2 Degree designation in Danish and English
The Master’s programme entitles the graduate to the designation civilingeniør, cand.polyt. (candidatus/candidata polytechnices) i trådløse kommunikationssystemer. The English designation is: Master of Science (MSc) in Engineering (Wireless Communication Systems).
2.3 The programme’s specification in ECTS credits
The Master’s programme is a 2-year, research-based, full-time study programme. The programme is set to 120 ECTS credits.

2.4 Competence profile on the diploma
The following competence profile will appear on the diploma:

A graduate of the Master’s programme has competencies acquired through an educational programme that has taken place in a research environment.

The graduate of the Master’s programme can perform highly qualified functions on the labour market on the basis of the educational programme. Moreover, the graduate has prerequisites for research (a Ph.D. programme). Compared to the Bachelor’s degree, the graduate of the Master’s programme has developed her/his academic knowledge and independence, so that the graduate can independently apply scientific theory and method in both an academic and occupational/professional context.

2.5 Competence profile of the programme:

The graduate of the Master’s programme:

Knowledge

- **Must know** fundamental theories and methods for analysis of a wireless communication system and its subcomponents,
- **Be able to understand** how to describe and account for a block level of a full wireless communication systems,
- **Must possess knowledge of** existing wireless communication systems, including their multiple access principle, basic terminology and overall architecture
- **Must know** some key features of international standards for one or several wireless communication systems
- **Must understand** channel allocation principles and radio resource management as it applies to wireless communication systems
- **Be able to understand** the terminology and methods used to characterize electromagnetic properties of antennas and propagation for wireless communication
- **Be able to understand** the terminology and parameters used to describe and characterize radio propagation mechanisms and channel response, including their impact to functionality and performance of multiple antenna systems

Skills

- **Must be able to choose between** a series of advanced analysis, simulation or experiments and model tests with relevance to wireless communication
- **Must be able to conduct** a study within a limited context and critically account for the observations and their implication
- **Must be able to plan** a wireless communication system for a given set of relevant system specifications and requirements
- **Must be able to evaluate and select** among different multi antenna or radio system techniques for channel stabilization and capacity enhancement
- **Must be able to characterize** propagation channel response
as relevant for the wireless communications formats under investigation

- **Must be able to choose** between and **apply** different numerical methods and theories, for the solution of electromagnetic antenna and wave propagation behaviors in wireless communication settings
- **Must be able to communicate** orally and in writing on topics within the field of knowledge, and in particular on the application of relevant techniques, procedures and algorithms used in the solution of the aforementioned problems.

## Competencies

- **Must be able to formulate and hypothesize** problems of relevance to the performance of practical wireless communication systems and critically **analyze** these on a link or system level
- **Must be able to account** for the complex multi-agent interaction on a link or system level
- **Must be able to choose between and apply** relevant methods and theories for evaluation and design of specific subsystems or components of particular wireless communication systems under investigations
- **Must be able to perform** a rational selection of practical communication system solutions, including a judicious selection of techniques, procedures and algorithms within the field of knowledge

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**Chapter 3: Content and Organization of the Programme**

The programme is structured in modules and organised as a problem-based study. A module is a programme element or a group of programme elements, which aims to give students a set of professional skills within a fixed time frame specified in ECTS credits, and concluding with one or more examinations within specific exam periods. Examinations are defined in the curriculum.

The programme is based on a combination of academic, problem-oriented and interdisciplinary approaches and organised based on the following work and evaluation methods that combine skills and reflection:

- lectures
- classroom instruction
- project work
- workshops
- exercises (individually and in groups)
- teacher feedback
- reflection
- portfolio work
Overview of the programme:

All modules are assessed through individual grading according to the 7-point scale or Pass/Fail. All modules are assessed by external examination (external grading) or internal examination (internal grading or by assessment by the supervisor only).

<table>
<thead>
<tr>
<th>Semester</th>
<th>Module</th>
<th>P/C*</th>
<th>ECTS</th>
<th>Assessment</th>
<th>Exam</th>
</tr>
</thead>
<tbody>
<tr>
<td>1&lt;sup&gt;st&lt;/sup&gt;</td>
<td>Wireless Radio Transmission</td>
<td>P</td>
<td>20</td>
<td>7-point scale</td>
<td>Internal</td>
</tr>
<tr>
<td></td>
<td>Stochastic Processes</td>
<td>C</td>
<td>5</td>
<td>7-point scale</td>
<td>Internal</td>
</tr>
<tr>
<td></td>
<td>Wireless PHY/MAC Fundamentals</td>
<td>C</td>
<td>5</td>
<td>Pass/Fail</td>
<td>Internal</td>
</tr>
<tr>
<td>2&lt;sup&gt;nd&lt;/sup&gt;</td>
<td>Wireless Communication in Dynamic Settings with focus on Antenna Systems (Elective)</td>
<td>P</td>
<td>25</td>
<td>7-point scale</td>
<td>External</td>
</tr>
<tr>
<td></td>
<td>Wireless Communication in Dynamic Settings with focus on Radio System (Elective)</td>
<td>P</td>
<td>25</td>
<td>7-point scale</td>
<td>External</td>
</tr>
<tr>
<td></td>
<td>Wireless Systems Performance</td>
<td>C</td>
<td>5</td>
<td>Pass/Fail</td>
<td>Internal</td>
</tr>
<tr>
<td>3&lt;sup&gt;rd&lt;/sup&gt;</td>
<td>Multi Agent Wireless Systems</td>
<td>P</td>
<td>20</td>
<td>7-point scale</td>
<td>Internal</td>
</tr>
<tr>
<td></td>
<td>Multi Agent Wireless Systems</td>
<td>C</td>
<td>5</td>
<td>Pass/Fail</td>
<td>Internal</td>
</tr>
<tr>
<td></td>
<td>Antennas and Propagation</td>
<td>C</td>
<td>5</td>
<td>Pass/Fail</td>
<td>Internal</td>
</tr>
<tr>
<td>A</td>
<td>Academic Internship</td>
<td>P</td>
<td>20&lt;sup&gt;1&lt;/sup&gt;, 25&lt;sup&gt;2&lt;/sup&gt;, 30</td>
<td>7-point scale</td>
<td>Internal</td>
</tr>
<tr>
<td>B</td>
<td>Academic Internship</td>
<td>P</td>
<td>20&lt;sup&gt;3&lt;/sup&gt;</td>
<td>7-point scale</td>
<td>External</td>
</tr>
<tr>
<td>C</td>
<td>Long Master’s Thesis</td>
<td>P</td>
<td>30</td>
<td>7-point scale</td>
<td>External</td>
</tr>
<tr>
<td>4&lt;sup&gt;th&lt;/sup&gt;</td>
<td>Master’s Thesis/Long master’s thesis</td>
<td>P</td>
<td>30</td>
<td>7-point scale</td>
<td>External</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>120</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* P = Project
  C = Course

<sup>1</sup> If choosing a 20 ECTS academic internship the student must earn the remaining credits on the 3<sup>rd</sup> semester by following the two courses under option A.
<sup>2</sup> If choosing a 25 ECTS academic internship the student must earn the remaining credits on the 3<sup>rd</sup> semester by following one of the two courses under option A.
<sup>3</sup> When writing a long master’s thesis the student must earn the remaining credits on the 3<sup>rd</sup> semester by following the two courses listed under option A.
Descriptions of modules

1st Semester

Wireless Radio Transmission (20 ECTS)
Trådløs radiotransmission

Objective:
Students who complete the module:

Knowledge
Must have knowledge about

- The impact of basic channel variations of stochastic nature - to communication system behavior
- Link budget establishment for a communication system
- Modern techniques for wireless radio transmission
- The block level description of a full wireless communication system (including transmitter, channel and receiver parts) – and the corresponding procedures required for its operation

Skills
The students must be able to

- Design, implement and analyze a solution to a practically occurring communication problem
- apply theories to transmit signals over stationary stochastic channel
- establish a communication system chain
- perform suitable test of implemented application to verify its consistency with established specifications.
- Must be able to communicate the result of the project work in appropriate form as relevant for scientific communication.
- Can explain the process of and criteria for peer reviewed scientific communications
- Can write a paper for a scientific conference/journal
- Can prepare and give an oral and poster presentation for a scientific conference

Competencies
The students must have ability to:

- make a basic design, test and verification of a wireless communication problem
  - generate a set of specifications to perform a stepwise refinement process of the given application

Type of instruction:
As described in the introduction to Chapter 3.

Exam format:
Individual oral examination
The examination is based on questions that take their starting points in the written documentation for the project module.

For further information concerning the examination procedure, refer to the Joint Programme Regulations.

Evaluation criteria:
As stated in the Joint Programme Regulations
Stochastic Processes (5 ECTS)
Stokastiske processer

Recommended academic prerequisites:
The module build on knowledge of probability, statistics, linear algebra, fourier theory, and programming

Objective:
Students who complete the module must:

Knowledge
• Have knowledge about the theoretical framework in which stochastic processes are defined.
• Be able to understand the properties of the stochastic processes introduced in the course, such as wide-sense stationary (WSS) processes, Auto Regressive Moving Average (ARMA) processes, Markov models, and Poisson point processes.
• Be able to understand how WSS processes are transformed by linear time-invariant systems.
• Be able to understand the theoretical context around the introduced estimation and detection methods ((non-parametric and parametric) spectral estimation, Linear Minimum Mean Square Error (LMMSE) estimation, Wiener filter, Kalman filter, detection of signals, ARMA estimation, etc.)

Skills
• Be able to apply the stochastic processes taught in the course to model real random mechanisms occurring in engineering problems.
• Be able to simulate stochastic processes using a standard programming language.
• Be able to apply the taught estimation and detection methods to solve engineering problems dealing with random mechanisms.
• Be able to evaluate the performances of the introduced estimation and detection methods.

Competencies
• Have the appropriate “engineering” intuition of the basic concepts and results related to stochastic processes that allow – for a particular engineering problem involving randomness – to design an appropriate model, derive solutions, assess the performance of these solutions, and possibly modify the model, and all subsequent analysis steps, if necessary.

Type of instruction:
As described in the introduction to Chapter 3.

Exam format:
Individual oral or written examination. For further information concerning the examination procedure, refer to the Joint Programme Regulations.

Evaluation criteria:
As stated in the Joint Programme Regulations.
Recommended academic Prerequisites:
The module builds on a basic understanding of wireless communications fundamentals, mathematics, and statistics as e.g. obtained on the BSc in Electrical Engineering or similar.

Objective:
Students who complete the module:

Knowledge
Must have knowledge about the following:

- Fundamental communication theory for wireless transmission
  - Classical communication theory
  - Noise handling in wireless communications
    - Loss and channel models (Friis transmission formula)
    - Analog chains, noise factor
    - Digital chains, coding
  - Detection and demodulation theory (coherent vs non-coherent)
- Transceiver architectures, blocks, and components
  - Transceiver structures and synchronization (incl. duplexing and access aspects)
  - Non-ideal components (non-linearities, compression and intercept)
  - Dynamic range and link budget
  - S-parameter description of components
  - RF/u-wave measurements of wireless communication blocks and chains
- Modeling and simulation of transceiver systems
  - Complex baseband representation of pass-band communication
  - Signal distortion due to block imperfections

Skills
Must be able to:

- Establish a link budget
- Synthesize a transceiver system on a block diagram level
- Describe the modifications that a signal undergoes through a transceiver chain
- Calculate key performance characteristics for a full transceiver chain based on specifications for the individual blocks
- Simulate the transmission of digital data through a full transceiver chain – including transmitter, lossy and noisy wireless channel, and receiver

Competencies
Must be able to:

- Discuss and evaluate the impact of different transceiver blocks in a communication link
- Set up a simulation model to access and evaluate the performance of (digital data) transmission over a wireless communication link
**Type of instruction:**
As described in the introduction to Chapter 3.

**Exam format:**
Individual oral or written examination.

**Evaluation criteria:**
As stated in the Joint Programme Regulations.
2nd Semester

Wireless Communication in Dynamic Settings with focus on Antenna System (Elective)  
(25 ECTS)  
Trådløs kommunikation under dynamiske forhold samt antennesystem

Recommended academic prerequisites:  
The module builds on knowledge obtained during the 1st semester

Objective:  
Students who complete the module:

Knowledge
Must have knowledge about

• Digital communication of analog or digital data over a stochastic fading channel.
• A basic wireless communication system and identify the individual blocks and their interaction. Thus, comprising the ends of the communication links, the transmission technique, the access technology as well as the fading channel
• Performance enhancing properties of multi antenna system or other technology, in a wireless communication system, with focus on the lower layers of the communication chain

Skills
The students must be able to

• Extract the specific operating conditions of selected system block(s) in context of the overall communication chain
• Compare and evaluate the individual stochastically varying links between two communicating entities.
• Evaluate the space and frequency dispersive behavior of the channel.
• Must be able to evaluate and select among different multi antenna techniques for channel stabilization and capacity enhancement.

Competencies
The students must have ability to:

• Analyze, evaluate and model a given wireless communication problem
• Communicate the project work in sound scientific and academic form
• Contribute successfully to team work within the problem area and make a common presentation of the project work

Type of instruction:  
As described in the introduction to Chapter 3.

Exam format:  
Individual oral examination with grades in accordance with the 7-point grading scale.
The examination is based on questions that take their starting points in the written documentation for the project module.
For further information concerning the examination procedure, refer to the Joint Programme Regulations.

Evaluation criteria:  
As stated in the Joint Programme Regulations.
Wireless Communication in Dynamic Settings with focus on Radio System (Elective)  
(25 ECTS)  
Trådløs kommunikation in dynamiske forhold samt radiosystem

**Recommended academic prerequisites:**  
The module builds upon knowledge obtained during the 1st semester

**Objective:**  
Students who complete the module:

**Knowledge**  
Must have knowledge about
- Digital communication of analogue or digital data over a stochastic fading channel.
- A basic wireless communication system and identify the individual blocks and their interaction. Thus, comprising the ends of the communication links, the transmission technique, the access technology as well as the fading channel
- Radio resources management in a multi-cell system, considering a space and frequency dispersive channel
- Channel allocation principles and its application to planning of wireless communication systems

**Skills**  
The students must be able to
- Extract the specific operating conditions of selected system block(s) in context of the overall communication chain
- Compare and evaluate the individual stochastically varying links between two communicating entities.
- apply and assess stabilization methods to compensate for these variations – and their impact on the wireless communication system capacity. Such as
  - Scheduling
  - Link adaptation
  - Channel allocation

**Competencies**  
The students must have ability to:
- Analyze, evaluate and model a given wireless communication problem
- Communicate the project work in sound scientific and academic form
- Contribute successfully to team work within the problem area and make a common presentation of the project work

**Type of instruction:**  
As described in the introduction to Chapter 3.

**Exam format:**  
Individual oral examination with grades in accordance with the 7-point grading scale.

The examination is based on questions that take their starting points in the written documentation for the project module.

For further information concerning the examination procedure, refer to the Joint Programme Regulations.
Evaluation criteria:
As stated in the Joint Programme Regulations.
Wireless Systems Performance (5 ECTS)
Trådløs system performance

Objective:
Students who complete the module:

Knowledge
Must have knowledge about the following:

- Link budget analysis
- Wave types
- Power vs protection margins
- Dynamic radio channel characterization
- Short terms descriptions
- Channel hardening/Diversity
- Radio Resource allocation
- Methods for fixed and dynamic channel allocation
- Cellular concept and hand-over
- Link and MAC control, Power control, AMC
- Wireless network performance and traffic analysis
- Dynamic routing
- Transport – congestion control – performance impact
- Wireless network architectures
- Short range infra-structures
- Cellular infra-structure

Skills
The students must be able to

- Establish a link budget with account for dynamic protection margins for a given wireless communication system
- Select the relevant metrics to establish and estimate Quality of Service (QoS) performance
- Establish radio resource requirements based on traffic load
- Evaluate feasibility of routing strategies based on system properties and requirements
- Evaluate and select different wireless networking architectures based on system requirements
- Evaluate properties of dynamic channels and apply stabilization techniques

Competencies
The students must be able to

- Analyze, evaluate and model the chain from PHY to Transport layer and how it combines towards the total performance and QoS of a wireless communication system

Type of instruction:
As described in the introduction to Chapter 3.

Exam format:
Individual oral or written examination. Grading according to the pass/fail. For further information
concerning the examination procedure, refer to the Joint Programme Regulations.

**Evaluation criteria:**
As stated in the Joint Programme Regulations.
3rd Semester

Multi Agent Wireless Systems (20 ECTS)

Recommended academic prerequisites:
The module builds upon knowledge obtained during the 1st and 2nd semester

Objective:
Students who complete the module:

Knowledge
Must have knowledge about

- Item the interaction of multiple communication links which are jointly considered to optimize system performance
- Wireless communications technologies for multi-user/multi-network setting.
- Specific in-depth knowledge about at least one advanced method or technology applied to wireless communications. Such as
- The generic multiple access principles as it applies to time, frequency, code and space - and know their advanced formats for multi agent support.
- Methods used to model electro-magnetic properties of antennas and propagation for wireless communication, and exploit their characteristics for terminal or system performance
- Channel characterization and processing algorithms to exploit multi link radio propagation mechanisms of multiple antenna systems

Skills
The students must be able to

- Evaluate the impact on system performance, by joint treatment of links in a multi-user/multi-network scenario – or other interaction mechanisms.
- Apply multi-agent or other modern/advanced techniques to a practical problem in modern wireless communications and evaluate their applicability
- Excel in least one advanced method or technology applied to wireless communications.

Competencies
The students must have ability to:

- Assess and exploit the space domain, the multiple user dimensions - or other modern/advanced technologies, to provide additional degrees of freedom to the system design.
- Communicate the project work in sound scientific and academic form
- Contribute successfully to team work within the problem area and make a common presentation of the project work

Type of instruction:
As described in the introduction to Chapter 3.

Exam format:
Individual oral examination with grades in accordance with the 7-point grading scale.
The examination is based on questions that take their starting points in the written documentation
for the project module.

For further information concerning the examination procedure, refer to Joint Programme Regulations.

**Evaluation criteria:**
As stated in the Joint Programme Regulations
Multi Agent Wireless Systems (5 ECTS)

Recommended academic prerequisites:
The module builds upon knowledge obtained during the modules Stochastic Processes (1st semester) and Wireless System Performance (2nd semester)

Objective:
Students who complete the module:

Knowledge
Must have knowledge about
- Advanced Access
- CDMA for multi-user systems
- Multicarrier systems (OFDM and OFDMA)
- Space division multiple access (SDMA)
- Distributed antenna systems
- Short range communications
- Passive communications/RFID-enabled devices
- Energy-cost-performance balancing
- Network level
- Device level
- Cooperative communications
- Ad-hoc
- Cognitive radio and dynamics spectrum sharing
- Network coding
- Space and time processing
- Spatial data multiplexing and space-time coding
- Time reversal techniques

Skills
The students must be able to
- Determine advantages vs disadvantages of a chosen access technique
- Compare different cooperative communication schemes and their operation in interference scenarios
- Assess different technology features on cost-resource balancing in practical settings
- Apply processing methods for time and space exploitation of the wireless radio channel

Competencies
The students must be able to:
- Compare and asses tradeoffs for performance optimization in heterogeneous (advanced) wireless communications.
- Choose the technology most suitable under given practical implications and limitations
**Type of instruction:**
As described in the introduction to Chapter 3.

**Exam format:**
Individual oral or written examination. Grading according to the pass/fail.
For further information concerning the examination procedure, refer to the Joint Programme Regulations.

**Evaluation criteria:**
As stated in the Joint Programme Regulations.
Antennas and Propagation (5 ECTS)
Antenner og Udbredelse

Recommended academic prerequisites:
The module builds upon knowledge of Electro-magnetics, and Antennas and their connection to stochastic radio channels. Moreover the module builds on knowledge obtained during the modules Wireless PHY/MAC Fundamentals (1st semester) and Wireless System Performance (2nd semester) or similar.

Objective:
Students who complete the module:

Knowledge
Must have knowledge about
- Antennas
- Basic antennas
- Requirements for antennas in a scattering radio environment
- Multi-antenna/ correlation analysis
- Antenna measurement principles
- Near field (antenna design)
- Finite Difference Time Domain (FDTD) Method
- Method of Moments
- Far field (propagation)
- Ray tracing
- Phase screen methods and diffraction
- Propagation scattering modeling for multiple antenna systems

Skills
- Identify connection between antenna system and radio channel behavior
- Assess performance of antenna elements and antenna systems
- Select appropriate Electro-magnetic near and far field Simulation methodology for realistic antenna and propagation settings

Competencies
- Apply antenna(system) and propagation conditions in new/real-world constellations for analyzing wireless communication system impact and performance optimization
- Evaluate limits of the methods and theories as applied to more general problems

Type of instruction:
As described in the introduction to Chapter 3.

Exam format:
Individual oral or written examination. Grading according to the pass/fail.

For further information concerning the examination procedure, refer to the Joint Programme Regulations.

Evaluation criteria:
As stated in the Joint Programme Regulations.
Academic internship
Projektorienteret forløb i en virksomhed

Prerequisites:
An academic internship agreement approved by the company, an AAU supervisor and the study board for electronics and it (ESN).

The academic internship must have a scope that correspond the ECTS load.

Purpose:
The student stays in a company with the purpose of learning and applying theories and methods to address engineering problems in an industrial context. In addition, the student will be introduced to business procedures and policies.

Objectives:
After completing the module, the student should have the following knowledge, skills and competencies:

Knowledge
- Has knowledge about the organization of the company and business procedures and policies.
- Has knowledge about performance measures in the company.
- Has developed a fundamental business sense.
- Has knowledge of the competence profile of the program and how the academic internship contributes to the competence profile.
- Has gained deepened knowledge into engineering theories and methods within the program.

Skills
- Can initiate and ensure the completion of an agreement for the academic internship, with learning objectives corresponding to the semester at the master’s program.
- Can apply analytic, methodological and/or theoretic skills to address advanced engineering problems in an industrial context.
- Can contribute in a professional manner to company objectives as an individual and in teams in accordance with the project management model applied in the company.
- Can collaborate and communicate with peers, managers and others.
- Can document the academic internship in a report and defend it orally.

Competencies
- Can discuss and reflect on the learning outcomes of the academic internship.
- Can discuss the need for knowledge transfer between academia and industry.
- Has a deepened understanding of the academic interests to pursue in the master’s thesis and possible job positions to aim at after graduation.

Type of instruction:
Project work

Exam format:
Oral examination based on a written report.

Evaluation criteria:
As stated in the Framework Provisions.
4th Semester

Master’s Thesis (30, possibly 50 ECTS)
Kandidatspeciale

The master thesis can be conducted as a long master thesis. If choosing to do a long master thesis, it has to include experimental work and has to be approved by the study board. The amount of experimental work must reflect the allotted ECTS.

Recommended academic prerequisites:
The master’s thesis builds upon the knowledge obtained during the 1st – 3rd semester

Objective:
Students who complete the module:

Knowledge
• have knowledge, at the highest international level of research, of at least one of the core fields of the education
• have comprehension of implications of research (research ethics)

Skills
• are able to reflect on a scientific basis on their knowledge,
• can argue for the relevance of the chosen problem to the education including specifically account for the core of the problem and the technical connections in which it appears
• can account for possible methods to solve the problem statements of the project, describe and assess the applicability of the chosen method including account for the chosen delimitation and the way these will influence on the results of the product
• can analyze and describe the chosen problem applying relevant theories, methods and experimental data
• are able to describe the relevant theories and methods in a way that highlights the characteristics and hereby document knowledge of the applied theories, methods, possibilities and delimitations within the relevant problem area
• have the ability to analyze and assess experimental data, including the effect the assessment method has on the validity of the results.

Competencies
• are able to communicate scientific problems in writing and orally to specialist and non-specialist.
• are able to control situations that are complex, unpredictable and which require new solutions,
• are able to independently initiate and to perform collaboration within the discipline and interdisciplinary as well, and to take professional responsibility,
• are able to independently take responsibility for his or her own professional development and specialization.

Type of instruction:
As described in the introduction to Chapter 3.

Problem based project oriented project work individual or in groups of 2-3 persons

Exam format:
Individual oral examination with grades in accordance with the 7-point grading scale. An external
censor is appointed.
The examination is based on questions that take their starting points in the written documentation for the project module.
For further information concerning the examination procedure, refer to the Joint Programme Regulations.

**Evaluation criteria:**
As stated in the Joint Programme Regulations.
Chapter 4: Entry into Force, Interim Provisions and Revision

The curriculum is approved by the Dean of The Technical Faculty of IT and Design and enters into force as of September 2018.

Students who wish to complete their studies under the previous curriculum from 2017 must conclude their education by the summer examination period 2019 at the latest, since examinations under the previous curriculum are not offered after this time.

Chapter 5: Other Provisions

5.1 Rules concerning written work, including the Master’s thesis
In the assessment of all written work, regardless of the language it is written in, weight is also given to the student's spelling and formulation ability, in addition to the academic content. Orthographic and grammatical correctness as well as stylistic proficiency are taken as a basis for the evaluation of language performance. Language performance must always be included as an independent dimension of the total evaluation. However, no examination can be assessed as ‘Pass’ on the basis of good language performance alone; similarly, an examination normally cannot be assessed as ‘Fail’ on the basis of poor language performance alone. The Board of Studies can grant exemption from this in special cases (e.g., dyslexia or a native language other than Danish).

The Master’s Thesis must include an English summary. If the project is written in English, the summary must be in Danish. The summary must be at least 1 page and not more than 2 pages. The summary is included in the evaluation of the project as a whole.

5.2 Rules concerning credit transfer (merit), including the possibility for choice of modules that are part of another programme at a university in Denmark or abroad
The Board of Studies can approve successfully completed (passed) programme elements from other Master's programmes in lieu of programme elements in this programme (credit transfer). The Board of Studies can also approve successfully completed (passed) programme elements from another Danish programme or a programme outside of Denmark at the same level in lieu of programme elements within this curriculum. Decisions on credit transfer are made by the Board of Studies based on an academic assessment. See the Joint Programme Regulations for the rules on credit transfer.

5.3 Rules for examinations
The rules for examinations are stated in the Examination Policies and Procedures published by the Technical Faculty of IT and Design on their website.

All students who have not participated in Aalborg University’s PBL introductory course during their Bachelor’s degree must attend the introductory course “Problem-based Learning and Project Management”. The introductory course must be approved before the student can participate in the project exam. For further information, please see the School of Information and Communication Technology’s website.

4 Or another foreign language (upon approval from the Board of Studies)
5 The Board of Studies can grant exemption from this.
5.4 Exemption
In exceptional circumstances, the Board of Studies study can grant exemption from those parts of the curriculum that are not stipulated by law or ministerial order. Exemption regarding an examination applies to the immediate examination.

5.5 Rules and requirements for the reading of texts
It is assumed that the student can read academic texts in his or her native language as well as in English and use reference works etc. in other European languages.

5.6 Additional information
The current version of the curriculum is published on the Board of Studies' website, including more detailed information about the programme, including exams.