The Faculty of Engineering and Science
The Study Board of Electronics and IT

Curriculum for Bachelor (BSc) in Electronics and Computer Engineering

Aalborg University

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Campus Esbjerg

PREFACE:

Pursuant to Act 367 of May 22, 2013 on Universities (the University Act) with subsequent changes, the following curriculum for the Bachelor's programme in Electronics and Computer Engineering is established. The programme also follows the Framework Provisions and the Examination Policies and Procedures for the Faculty of Engineering and Science.

AAU, November 2013

Uffe Kjærulff
Director of studies

Table of contents

Chapter 1: Legal Basis of the Curriculum, etc.

1.1 Basis in ministerial orders

The Bachelor's programme in Electronics and Computer Engineering is organised in accordance with the Ministry of Science, Innovation and Higher Education's Order no. 814 of June 29, 2010 on Bachelor's and Master's Programmes at Universities (the Ministerial Order of the Study Programmes) and Ministerial Order no. 666 of June 24, 2012 on University Examinations (the Examination Order) with subsequent changes. Further reference is made to Ministerial Order no. 1487 of December 16, 2013 (the Admission Order) and Ministerial Order no. 250 of March 15, 2007 (the Grading Scale Order) with subsequent changes.

1.2 Faculty affiliation

The Bachelor's programme falls under the Faculty of Engineering and Science.

1.3 Board of Studies affiliation

The Bachelor's program falls under the Board of Studies for Electronics and IT.

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

2.1 Admission

Admission to the Bachelor's programme in Electronics and Computer Engineering requires an upper secondary education.

The program's specific requirements are: English B, Mathematics A and Physics B or Geoscience A according to admission notice. All subjects must be passed.

2.2 Degree designation in Danish and English

Bachelor of Science (BSc) in Engineering (Electronic and Computer Engineering). The Danish designation is Bachelor (BSc) i teknisk videnskab (elektronik og datateknik)

2.3 The programme's specification in ECTS credits

The Bachelor's programme is a 3-year, research-based, full-time study programme. The programme is set to 180 ECTS credits.

2.4 Competence profile on the diploma

The following will appear on the diploma:

> A graduate of the Bachelor's programme has competencies acquired through an educational programme that has taken place in a research environment.
>
> A graduate of the Bachelor's programme has fundamental knowledge of and insight into his/her subject's methods and scientific foundation. These properties qualify the graduate of the Bachelor's programme for further education in a relevant Master's programme as well as for employment on the basis of the educational programme.

2.5 Competence profile of the programme:

<u>The graduate of the Bachelor's programme:</u>

Knowledge

- Has knowledge of and insight into fundamental theories, methods and practical subjects within the field of Electronics and Computer Engineering
- Is able to understand and reflect upon theories, methods and practical subjects within the field
- Has a firm grasp of the mathematical and programming foundations of the field
- Can analyse, design, implement, test and document micro-processor-based systems
- Has knowledge of the interaction between electronic and physical systems, including feedback mechanisms, electronic circuits, automation and control systems, and signal processing
- Has insight into techniques and methods for real-time acquisition, storage and processing of complex information
- Has insight into analysis, design and test methods for feedback control and digital signal processing

Skills

- Can utilize up-to-date scientific methods, tools and techniques to analyse and solve complex problems in the field of Electronics and Computer Engineering
- Can evaluate and compare theoretical and practical problems, as well as describe and select relevant solution strategies
- Is able to implement such solution strategies and evaluate them in a systematic manner
- Is able to present problems and solution strategies within the field of Electronics and Computer Engineering, in writing as well as orally, to specialists as well as non-specialists, including external parties, users, etc.

Competencies

- Is able to handle complex situations that arise in research and/or development-related environments, such as university studies and/or engineering workplaces.
- Is able to develop and test hardware and software for embedded systems in a broad systems-oriented context
- Can work independently as well as in collaboration with others, both within and across technical fields, in an efficient and professional manner
- Is able to identify his/her own learning needs and structure his/her own learning in various learning environments

Chapter 3: Content and Organisation 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. The 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

3.1 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 assessment by the supervisor only).

Semester	Module	ECTS	Assessment	Grading
ED1	Technological Project Work	5	Pass/Fail	Internal
	Monitoring & Programming	10	7 grade scale	Internal
	Imperative Programming	5	Pass/Fail	Internal
	Problem Based Learning in Science, Technology and Society	5	Pass/Fail	Internal
	Linear Algebra	5	7 grade scale	Internal
ED2	Analog Instrumentation	15	7 grade scale	External
	Calculus	5	7 grade scale	Internal
	Basic Electrical Engineering	5	7 grade scale	Internal
	Digital Design & Sensors	5	Pass/Fail	Internal
ED3	Micro Processor Based Systems	15	7 grade scale	External
	AC-Circuits & Electro Physics	5	7 grade scale	Internal
	Advanced Calculus	5	7 grade scale	Internal
	Micro Processors & Programming	5	Pass/Fail	Internal
ED4	Control Engineering	15	7 grade scale	Internal
	Modelling & Simulations	5	7 grade scale	Internal
	Control Theory	5	7 grade scale	Internal
	Power Electronics & Networks	5	7 grade scale	Internal
ED5	Automation*	15	7 grade scale	External
	Digital Filtering*	15	7 grade scale	External
	Numerical Methods	5	7 grade scale	Internal
	Signal Processing	5	Pass/Fail	Internal
	Real-time Embedded Systems	5	Pass/Fail	Internal
ED6	BSc Project (Automation and Control)*	20	7 grade scale	External
	BSc Project (Embedded Real-time Signal Processing)*	20	7 grade scale	External
	Introduction to probability theory and statistics	5	Pass/Fail	Internal
	Matrix computation and convex optimization	5	Pass/Fail	Internal

* Elective module

Throughout the semesters students will at an increasing abstraction level be introduced to relevant theories and scientific methods. Scientific theory and scientific methods in general are included in the course Problem based learning in science, technology and society. Moreover, the students develop their skills in this area in their project work, where they will apply scientific methods in practice and reflect on their application.

3.2 Descriptions of modules

Technological Project Work
Teknologisk projektarbejde

Semester: 1st semester

Purpose: Through this module, the student shall acquire knowledge about problem oriented and problem based learning. Furthermore, he/she shall acquire first-hand knowledge about project-oriented group work as a learning method. Additionally, the student will be introduced to basic problems and concepts within the field of Electronics and IT.

Objectives: After completion of the module, the student:

Knowledge

- Shall have insight into elementary concepts related to project-oriented group work.
- Shall be familiar with the processes involved in project work, knowledge acquisition and supervisor collaboration

Skills

- Shall be able to define project goals and work in a methodical manner toward achieving such goals
- Shall be able to describe and analyse several approaches to project solutions
- Shall be able to present results achieved within the project in writing, orally, and graphically in a comprehensive manner.

Competencies

- Shall be able to reflect upon the problem oriented and problem based learning approach taken throughout the study
- Shall be able to document the results achieved during the project in a report
- Shall be able to cooperate with other students during the project period and make a joint presentation of the results achieved in the project.
- Shall be able to reflect upon different ways of presenting results achieved with the project in writing, orally, and graphically.

Content: The project group must prepare a report and process analysis, participate in a P0 collection of experience and attend a presentation seminar where the project group documents discussed.

Type of instruction: Project work with supervision

Exam format: Individual oral examination based on a written report

Evaluation criteria: Stated in the Framework Provisions

Monitoring & Programming
Overvågning og programmering

Semester: 1st semester
Prerequisites: Technological project work (P0)
Purpose: One of the most fundamental capabilities any electronics and computer Engineer must possess is the ability to construct functionality that allows a computer to interact with its surroundings. Through the 1st semester project, the students shall acquire basic knowledge within electronics and computer engineering through practical and theoretical work. The project takes its starting point in a problem of relevance to society or industry; the problem is then broken down into smaller, more manageable sub-problems and analysed for the purpose of defining a relevant technical problem formulation, which can be solved via theories and methods related to micro-processor- or PC- based systems. The solution shall encompass an electronic system containing (at least) a programmable electronic computing device, which is able to measure signals from its surroundings via selected sensors and process them in some digital form.

Objectives: Students who complete the module:

Knowledge

- Must have understanding of basic electronic systems and their interaction with their surroundings
- Must have basic insight into concepts such as signals, sensors, actuators and micro-processors
- Shall have sufficient insight into technological and social issues to enable them to pinpoint relevant problems that can be solved by technical means
- Shall have knowledge about common processes in extensive, problem-oriented projects
- Shall be able to explain and clarify theories and methods used in the project

Skills

- Given a socially relevant problem, must be able to identify relevant requirements to a technical solution, product or similar
- Must be able to follow a relevant method for structured development in the project, including formulation and analysis of the problem, define a requirement specification and divide the problem into sub-problems that can be resolved separately
- Shall be able to utilize the selected sensors and actuators for data collection and interaction with an electronic system and its surroundings as well
- Shall be able to formulate and solve technical problems via algorithms and be able to implement algorithms in a micro-processor or similar programmable device

- Shall be able to analyse and evaluate their own utilization of taught theories and methods
- Shall be able to document and present the knowledge and skills outlined above, using correct terminology, in writing as well as orally
- Shall be able to analyse and evaluate their own learning processes using relevant methods
- Shall be able to plan and carry out an extensive group project in collaboration with a supervisor

Competencies

- Shall understand the general concept of a system, in particular pertaining to electronic systems interacting with their surroundings
- Shall be able to assume responsibility for their own learning processes during an extensive group project, as well as generalize and interpret the experience acquired
- Shall be able to plan, structure, carry out, and reflect upon a project that starts from a socially or industrially relevant problem, in which electronic systems and information technology is an important element, individually as well as in groups.

Type of instruction:	Project work with supervision
Examination:	Oral examination based on a written report
Evaluation criteria:	Stated in the Framework Provisions

Imperative Programming
Imperativ programmering

Semester: 1st semester

Purpose: Students who complete the module enrich their background in working with computers and other digital devices in procedural ways to enable programming for different media platforms and working with analog and digital sensors.

Objectives: Students who complete the course module

Knowledge

- Shall have understanding of integrated development environments
- Shall have understanding of differences between run-time and compile-time computer programming languages
- Shall be able to explain the concepts of types, declarations, expressions and statements
- Shall be able to make use of libraries and understand the concept of linking
- Shall have insight into data structures, such as arrays
- Shall have insight into input/output in various forms
- Shall have understanding of procedures and functions, including function arguments
- Shall have understanding of pointers and references
- Shall have understanding of the complexity of a program
- Shall have understanding of simple algorithms

Skills:

- Shall be able to interpret and analyse a basic imperative program and elaborate its functionality
- Shall be able to design and implement algorithms for data structure manipulation using references and addresses where necessary
- Shall be able to estimate the complexity of a program
- Shall be able to explain how to use algorithms, functions and data for solving problems (understanding)

Competencies:

- Must be able, individually and in collaboration with others, to design and implement one or more imperative program(s) to solve a previously specified problem

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

Exam format: Individual oral or written examination

Evaluation criteria: Stated in the Framework Provisions

Problem Based Learning in Science, Technology and Society
Problembaseret læring i videnskab, teknologi og samfund

Semester: 1st semester

Purpose: To enable the student to approach real-life complex problems in a methodical manner, and to carry out project work, planning and documentation in a structured way.

Objectives: Students who complete the course module will obtain the following qualifications:

Knowledge

- Shall be able to explain basic learning theory
- Shall be able to explain techniques for planning and management of projects
- Shall be able to explain different approaches to problem-based learning (PBL), including the so-called Aalborg model based on problems that are part of a social and/or humanistic context
- Shall be able to explain different approaches to analysis and assessment of problems and solutions within engineering, natural and health sciences from a theoretical, ethical, and societal perspective
- Shall be able to explain how these methods can be applied within electronics and computer engineering

Skills

- Must be able to plan and manage a problem-based study project
- Must be able to analyse the project group's organization and cooperation in order to identify strengths and weaknesses, and suggest how cooperation in future groups can be improved based on this analysis
- Must be able to reflect on the causes and devise possible solutions to any group conflicts
- Must be able to analyse and evaluate their own study work and learning, in order to identify strengths and weaknesses, and use these reflections to consider further study and group work
- Must be able to reflect upon the methods used from a theoretical perspective
- Must be able to identify relevant areas of focus, concepts and methods to assess and develop technical solutions under consideration of the social and humanistic contexts that solution must be a part of

Competencies

- Shall be able to take part in a team-based project
- Shall be able to document and present work carried out in a project
- Shall be able to reflect upon and develop his/her own learning

- Shall be able to engage in and improve upon the collaborative learning processes
- Shall be able to reflect upon his/her professional activities in relation to the surrounding community

Type of instruction:	As described in the introduction to Chapter 3.
Exam format:	Individual oral or written examination
Evaluation criteria:	Stated in the Framework Provisions

Linear Algebra
Lineær algebra

Semester:	1st semester
Purpose	Linear algebra is a fundamental tool for virtually all engineering mathematics
Objectives:	Students who complete the module:

Knowledge

- Shall have knowledge about definitions, results and techniques within the theory of systems of linear equations
- Shall be able to demonstrate insight into linear transformations and their connection with matrices
- Shall have obtained knowledge about the computer tool MATLAB and how it can be used to solve various problems in linear algebra
- Shall have acquired knowledge of simple matrix operations
- Shall know about invertible matrices and invertible linear mappings
- Shall have knowledge of the vector space R^n and various subspaces
- Must have knowledge of linear dependence and independence of vectors and the dimension and bases of subspace
- Must have knowledge of the determinant of matrices
- Must have knowledge of Eigen values and eigenvectors of matrices and their use
- Must have knowledge of projections and orthonormal bases
- Must have knowledge of first order differential equations, and on systems of linear differential equations

Skills

- Must be able to apply theory and calculation techniques for systems of linear equations to determine solvability and to provide complete solutions and their structure
- Must be able to represent systems of linear equations using matrix equations, and vice versa
- Must be able to determine and apply the reduced Echelon form of a matrix
- Must be able to use elementary matrices for Gaussian elimination and inversion
  of matrices
- Must be able to determine linear dependence or linear independence of small sets of vectors
- Must be able to determine the dimension of and basis for small subspaces

- Must be able to determine the matrix for a given linear transformation, and vice versa
- Must be able to solve simple matrix equations
- Must be able to calculate the inverse of small matrices
- Must be able to determine the dimension of and basis for kernel and column spaces
- Must be able to compute determinants and could use the result of calculation
- Must be able to calculate Eigen values and eigenvectors for simple matrices
- Must be able to determine whether a matrix is diagonalizable, and if so, implement a diagonalization for simple matrices
- Must be able to compute the orthogonal projection onto a subspace of R^n
- Must be able to solve separable and linear first order differential equations, in general, and with initial conditions

Competencies

- Shall demonstrate development of his/her knowledge of, understanding of, and ability to make use of, mathematical theories and methods within relevant technical fields
- Shall, given certain pre-conditions, be able to make mathematical deductions and arguments based on concepts from linear algebra

Type of instruction:	As described in the introduction to Chapter 3.
Exam format:	Individual oral or written examination
Evaluation criteria:	Stated in the Framework Provisions

Analog Instrumentation
Analog instrumentering

Semester:	2nd semester
Prerequisites:	Monitoring and programming (P1)
Purpose:	Through theoretical and practical work on a selected problem, the students acquire knowledge in the electronics and computer engineering discipline, as well as use appropriate methods to document that the problem has a relevant social context. The problem is analysed by decomposition into sub problems in order to formulate a technical problem that can be solved by using analog electronic systems that interact with the environment in one way or another. The complete solution is assessed with respect to the relevant social context. Compared to the first semester, this semester focuses more on the continuous-time (analog) aspects of electronic systems as well as interaction with the surroundings in greater detail.
Objectives:	Students who complete the module:

Knowledge

- Shall have gained experience with theories and methods of calculation and simulation of linear electronic circuits, linear electro-mechanical systems, and/or other linear systems
- Shall have acquired knowledge of methods for analysis of linear dynamic systems, including electronic circuits, described by differential equations
- Shall have gained insight into basic feedback theory and its applications in electronic systems
- Must master calculations with complex numbers, as used within the field of electronics
- Shall have knowledge of recognized standards for documentation of electronic circuits, including electrical diagrams, PCB layout, etc.
- Shall be able to demonstrate knowledge of theory and method to the extent of being able to explain and justify the project's theory and methods, including both selection and de-selection.
- Shall master the relevant terminology

Skills

- Shall have understanding of basic theories behind simple electronic components such as resistors, capacitors, operational amplifiers, etc., including calculation of these components
- Shall be able to identify, analyse and formulate issues within the discipline through the use of contextual and technical analysis methods
- Shall, based on the above, be able to create requirements and test specifications that enable the completed system to be

tested rigorously
- Shall be able to use mathematical theories and methods to analyse problems involving linear dynamic components
- Shall be able to simulate and design simple analog circuits, allowing specific, desired properties to be achieved.
- Shall be able to design and implement basic analog and digital circuits and demonstrate that these work as intended
- Shall be able to document and disseminate knowledge and skills with proper use of terminology, orally and in writing through a project report
- Shall be able to analyse and reflect upon his/her own learning process using appropriate methods of analysis and experience from P0 and P1
- Shall be able to analyse a technical-scientific problem under consideration of technological and societal contexts, and assess the technological and social consequences of proposed solutions.

Competences

- Must be able to demonstrate, independently and in groups, the ability to plan, organize, implement and reflect upon a project that is based on a problem of relevance to society or industry, in which analog electronic devices play a central role
- Must have acquired, independently and in groups, the ability to obtain the necessary knowledge of a contextual as well as of technical nature, and be able to formulate models of limited parts of reality to such a level of abstraction that the models can be used in the design, implementation and test of a comprehensive system to meet given requirements
- Must be able to evaluate and take responsibility for science and technical solutions in a societal perspective.
- Must be able to generalize and reflect upon the experience with project planning and cooperation for the further study acquired during the project work

Type of instruction:	Project work with supervision
Exam format:	Oral examination based on a written report
Evaluation criteria:	Stated in the Framework Provisions

Calculus
Calculus

Semester: 2^{nd} semester
Prerequisites: Linear algebra
Purpose: Calculus is the branch of mathematics that studies differential equations and operations such as integration. Differential equations, in turn, describe (among other things) how signals in electric circuits behave

Objectives: Students who complete the module:

Knowledge

- Must have knowledge of definitions, results and techniques within the theory of differentiation and integration of functions of two or more variables
- Must have knowledge of the trigonometric functions and their inverse functions
- Must have knowledge of complex numbers, including rules for computation and their representations
- Must have knowledge of factorization of polynomials over the complex numbers
- Must have knowledge of the complex exponential function, its characteristics and its
  connection with trigonometric functions
- Must have knowledge of curves in the plane (both rectangular and polar coordinates) and spatial parameterizations, tangent vectors and curvatures of such curves
- Must have knowledge of the theory of second order linear differential equations with constant coefficients

Skills

- Must be able to visualize functions of two and three variables using graphs, level curves and level surfaces
- Must be able to determine local and global extreme for functions of two and three variables
- Must be able to determine area, volume, moment of inertia etc. using integration theory
- Must be able to approximate functions of one variable using Taylor's formula, and use linear approximations for functions of two or more variables
- Must be able to perform arithmetic computations with complex numbers
- Must be able to find the roots in the complex quadratic equation and perform factorization of simple polynomials
- Must be able to solve linear second order differential equations with constant coefficients, in general, and with initial conditions

- Must be able to use the concepts, findings and theories introduced in the course to make mathematical deductions in the context of simple and concrete abstract problems

Competencies

- Shall demonstrate development of his/her knowledge of, understanding of, and ability to make use of, mathematical theories and methods within relevant technical fields
- Shall, given certain pre-conditions, be able to make mathematical deductions and arguments based on concepts from multi-variable calculus

Type of instruction:	As described in the introduction to Chapter 3.
Exam format:	Individual oral or written examination
Evaluation criteria:	Stated in the Framework Provisions

Basic Electrical Engineering
Grundlæggende elektronik

Semester: 2nd semester
Prerequisites: Monitoring and programming (P1) or 1st semester of Electronics and IT or Energy studies
Purpose: To give the students theoretical and practical insight into analog electronic devices, their models, and how to use them in the design of electronic systems

Objectives: Students who complete the module:
Knowledge

- Must have knowledge and understanding of resistive electrical circuits
- Must have knowledge and understanding of operational amplifiers
- Must have knowledge and understanding of analog electronics, including diodes and transistors
- Must have knowledge and understanding of electrical measurement techniques
- Must have knowledge and understanding of laboratory safety of electro technical laboratory experiments
- Must have knowledge of Basic DC Circuit Theory (without energy storing components) including
  - Ohm's law
  - Kirchhoff's laws
  - Circuit reductions (serial and parallel)
  - Star-triangle dependent and independent sources
  - The focal point and mask method
  - Basic operational amplifier couplings
  - The ideal operational amplifier
  - Thévenin and Norton theorems, the superposition principle, and the maximum power transfer principle.
- Must have knowledge of PN transitions including
  - The diode and its stationary large / small-signal model diode as rectifier
  - Transistor and its use as a linear amplifier
  - The transistor as a switch
  - Semiconductor models in simulation software
- Must have knowledge of measurement theory including
  - Measurement of voltage, current, power and energy
  - Measuring instruments such as voltmeter, ampere meter, wattmeter as well as multi-meter and oscilloscopes
  - Accuracy, complex measurement errors and uncertainty

calculations

- Must have knowledge of relevant rules and regulations

Skills

- Must be able to analyse simple and complex electrical DC circuits
- Must be able to use circuit analysis techniques to calculate currents, voltages, energy and power in DC circuits
- Must be able to use circuit reduction methods to simplify electrical circuit models
- Must be able to apply and analyse electrical DC circuits with diodes and transistors
- Must be able to use analysis methods to design the operational amplifier couplings
- Must be able to plan and execute well-designed, successful electro technical laboratory experiments in a safe and appropriate manner

Competencies

- Must be able to handle simple development-oriented situations related to electric circuits and laboratory setups in study- or work-related contexts
- Must be able to independently engage in professional and interdisciplinary collaboration with a professional approach within the context of basic electrical engineering
  Must be able to identify his/her own learning needs within basic circuit theory and the electro technical laboratory experiments, and structure such learning accordingly.

Type of instruction:	As described in the introduction to Chapter 3. Notice that attendance at lab exercises is mandatory.
Exam format:	Individual oral or written examination
Evaluation criteria:	Stated in the Framework Provisions

Digital Design & Sensors
Digital design og sensorer

Semester: 2^{nd} semester
Prerequisites: Monitoring and programming (P1)
Purpose: To help the students to acquire knowledge and skills which enable the analysis and designing of basic digital circuits, they acquire knowledge about various sensors and develop skills to use and monitor the signals. To teach the operating principles of various typical sensors and to introduce the concepts & designs for the measurement of electrical and non-electrical quantities.

Objectives: Students who complete the module:

Knowledge:
- Must have knowledge and understanding of basic digital circuits
- Must have knowledge of Boolean algebra and minimal methods
- Must be able to explain the difference between CMOS and TTL circuits
- Must have knowledge of Multi-vibrators & Sequential circuits.
- Must have knowledge of Bi-stable Circuits, structure of mono-stable and a-stable circuits.
- Must have knowledge of Mealy and Moore State Machines
- Must have knowledge of Counters and Shift Registers
- Must have knowledge of different sensors
- Must have knowledge of how signal is obtained from different sensors
- Must have knowledge of internal working principal of various sensors.

Skills:
- Must be able to analyse simple digital circuits
- Must be able to design digital circuits which is a central feature of data or electrical engineering
- Must be able to understand the analysis, design and the realization of digital circuits
- Must be able to demonstrate an understanding of relevant concepts, theories and methods of analysis and synthesis of combinational and sequential networks.
- Must be able to apply concepts, theories and methods to describe and analyse a specific problem and explain the theoretical and practical implementation considerations.
- Must be able to outline the main electrical characteristics of logic building blocks.
- Must be able to demonstrate knowledge of different logical networks, including both combinational and sequential
- Must be able to model and synthesize digital circuits.
- Must be able to use Karnaugh Map to simplify circuit design

- Must be able to use measurements terminologies including resolution, sensitivity, accuracy, and uncertainty
- Must be able to use sensors for example for the measurement of temperature, displacement and position, digital encoders, shaft encoders, absolute and relative encoders, linear encoders.

Competencies:

- Must be able to handle simple development-oriented situations related to digital circuits design, sensors and laboratory setups in study- or work-related contexts
- Must be able to independently engage in professional and interdisciplinary collaboration with a professional approach within the context of digital electronics and sensor measurements
- Must be able to identify his/her own learning needs within digital electronics and sensor technology theory and the electro technical laboratory experiments, and structure such learning accordingly.

Type of instruction:	As described in the introduction to Chapter 3.
Exam format:	Individual oral or written examination
Evaluation criteria:	Stated in the Framework Provisions

Micro Processor Based Systems
Microprocessor-baserede systemer

Semester:	3^{rd} semester
Prerequisites:	Knowledge of electronics corresponding to analog Instrumentation (2nd semester)
Purpose:	Students shall understand the fundamental principles of microprocessor based systems and be able to construct and program a specific microprocessor based system so as to handle a small sized practical problem.

Objectives: Students who complete the module:

Knowledge:

- Be able to build and program a microprocessor based system
- Must have knowledge of the methodology used for constructing connected digital systems, including an introduction to fundamental digital circuits, their use and limitations
- Must have insight of basic terminology for the architecture of microprocessors

Skills:

- Be able to synthesize a microprocessor based system based on a specific technical problem, with the possibility of simple interaction between a user and surroundings
- Be able to modularize the total system into hardware and software with well-defined interfaces
- Be able to determine the architecture with regard to hardware and software and communication between subsystems
- Must be able to design a microprocessor program which can runs on its own for controlling the digital/analog hardware
- Must be able to elaborate a number of possibilities for analysis, program development, programming and testing for the entire microprocessor based system
- Be able to synthesize, document and bring the entire system (hardware and software) to working condition

Competencies:

- Be able to analyse and specify the design requirement through problem domain analysis
- Be able to design a microprocessor based system based on the design specifications
- Be able to implement and test the developed system with the purpose of verifying the hypothesis, as well as draw conclusions based on the achieved result.

Type of instruction:	Project work with supervision
Exam format:	Oral examination based on a written report
Evaluation criteria:	Stated in the Framework Provisions

AC-Circuits & Electro Physics
AC kredsløbsteori og elektrofysik

Semester: 3rd semester

Prerequisites: Knowledge of electronics corresponding to analog instrumentation (2nd semester)

Purpose: To teach students with fundamental knowledge of AC circuits and electro physics. To enable them to do analysis about static, quasistatic and dynamic electrical circuits connecting with combined electrical and magnetic fields

Objectives: Students who complete the module:

Knowledge:

- Have knowledge of static and quasistatic electrical and magnetic fields, capacity and inductance
- Must be able to understand and analyse circuits containing resistive, capacitive and inductive elements
- Must be able to understand and analyse stationary AC-circuits using complex symbolic methodology
- Must be able to understand and use Laplace transformation to analyse of dynamic electrical circuits

Skills:

- Must be able to analyse static and quasistatic electrical and magnetic fields and their usage
- Must be able to apply electro physics to determine electrical resistance, capacitance and inductance
- Must be able to apply electro physics to calculation of mechanical forces produced by electrical and magnetic fields
- Must be able to analyse stationary conditions in circuits containing resistive, capacitive and inductive elements
- Must be able to analyse electrical circuits dynamic conditions
- Must be able to apply methods for analyse of frequency conditions (amplitude and phase characteristic)
- Must be able to apply complex symbolic methodology for calculating stationary AC-circuits
- Must be able to analyse current, voltage, energy and power conditions in AC-circuits
- Must have skills within Electro physics including
  - Electrical fields, Displacement, electrical field strength, permittivity, Coulombs law, dielectric polarisation, Electrical potential.
  - Energy in electrical fields, Gauss' law, capacitance for simple geometries, electric flux, capacitors and capacitance
  - Magnetic fields, flux intensity and magnetic field strength, permeability, Biot-Savarts magnetic polarisation, Ampère's

law and magnetic flux

    - Inductance, magnetic forces on conducting conductors, torque on current loops in homogeny magnetic fields and magnetic forces between two parallel conductors, and coils
    - The generalized form of Ampére's law
    - Faraday's law, induced electromotive force, the electric generator
    - Lenz' law
    - Maxwell's equations
    - Ferromagnetic materials, hysteresis, B-H curves, energy in magnetic fields, vortex losses

- Must have skills in elementary circuit theory including
  - Energy storing components (L and C), initial values (L(0) and C(0))
  - First order systems, solving circuit equations of first order, Universal method
  - Second order systems, damping and natural frequency (θ and ω), solving circuit equations of second order (over damped, under damped and critically damped)
  - Transfer functions and usage of Laplace transformation on electrical circuits
  - Frequency analysis and Bodepots (amplitude and phase characteristics)
  - Resonance circuits
  - Poles and zeroes analysis
  - Frequency analysis
  - Filter networks
  - Fourier analysis
- Must have skills in elementary AC-circuits theory including
  - The complex symbolic methodology for calculating AC-circuits (single phased)
  - Impedance and admittance principle for stationary circuits
  - Power in AC-circuits, immediate power, average power, RMS, active and reactive power, power factor
  - Phasordiagrams for calculating stationary AC-circuits
  - Mutual inductance, coupling factor, single phase transformer

Competencies:

  - Shall be able to handle simple development oriented situations regarding electro physics and circuit technical problems in study- or work situations
  - Shall independently be able to engage in disciplinary and interdisciplinary corporations with a professional approach within elementary electrical and physics theory and methods.

- Must be able to identify own learning needs and structure own learning within electro physics and dynamical electrical circuits

Type of instruction:	As described in the introduction to Chapter 3.
Exam format:	Individual oral examination based on a written report
Evaluation criteria:	Stated in the Framework Provisions

Advanced Calculus
Videregående calculus

Semester: 3rd semester

Prerequisites: linear algebra, calculus

Purpose: The dynamical behaviour of systems is typically described by differential equations. This course supports the semester theme by providing mathematical tools for analysing such systems in detail.

Objectives: Students who complete the module:

Knowledge:

- Must have knowledge of important results within vector analysis in 2 and 3 dimensions
- Shall be able to understand Laplace transformation and use it to solve differential equations.
- Must have knowledge of complex analytic functions
- Must have an understanding of power series and Taylor series
- Must have knowledge of Laurent series and the method of residues integration

Skills

- Must be able to use vector analysis, including inner product, vector product, vector functions, scalar functions and fields, as well as elements of vector differential and integral calculus
- Must have understanding of Fourier series, including concepts such as trigonometric series, periodic functions, even and odd functions, complex Fourier series and forced oscillations resulting from non-sinusoidal input
- Shall be able to understand and utilize the Laplace transform for analysis of differential equations; specific subjects include:
    - The definition of the Laplace transforms.
    - Inverse transformation.
    - Linearity and s-shift.
    - Transformation of common functions, including regular, impulse and step functions.
    - Transformation of derivatives and integrals.
    - Solving Differential Equations
    - Folding and integral equations
    - Differentiation and integration of transformed systems of ordinary differential equations
    - Using Tables

- Shall be able to use complex analytical functions within the contexts of conformal mappings and complex integrals; specific subjects include:
    - Complex numbers and complex plane
    - Polar form of complex numbers
    - Exponential, trigonometric and hyperbolic functions
    - Logarithmic functions and general power functions
    - Complex Integration: Line integrals in the complex plane
    - The Cauchy integral theorem

	Competencies • Shall demonstrate development of his/her knowledge of, understanding of, and ability to make use of, mathematical theories and methods within relevant technical fields • Shall be able to identify their own learning requirements and structure their own learning within the context of fundamental mathematics.
Type of instruction:	As described in the introduction to Chapter 3.
Exam format:	Individual oral or written examination
Evaluation criteria:	Stated in the Framework Provisions

Micro Processors & Programming
Mikroprocessorer og programmering

Semester:	3rd semester
Prerequisites:	imperative programming; digital design and sensors
Purpose:	Most mechatronic systems include dedicated computers that handles the ”intelligent” tasks of guidance, monitoring and control. Typically, such a dedicated computer is connected to/equipped with sensors that allow it to measure important information about current system status and (in some cases) its surroundings. Using these measurements, the dedicated computer executes various algorithms that enable it to determine how to operate the mechatronic system's actuators in response to the immediate situation. Building on the knowledge gained in the 2nd semester, this course aims to provide the students with theories and methods that enable them to design and implement programs for such dedicated computers and use them in a practical system context.
Objectives:	Students who complete the module: *Knowledge:* • Shall have understanding of basic real-time aspects of single-processor system operation, including clock frequency, sampling rate, algorithm processing time etc., as well as how these aspects affect each other • Must have insight into common micro-processor architecture elements, such as RAM, ALU, registers, buses, etc., as well as how these components interact • Shall have insight into number representation on digital computers • Must have basic insight into simple digital filtering functionality • Must be able to use relevant tools to find a digital implementation of a continuous-time differential equation *Skills:* • Must be able to design algorithms for a chosen micro-processor that satisfy specified timing constraints • Must be able to use a relevant programming language, along with relevant compilers and linkers, to implement and test said algorithms on said micro-processor • Must be able to design and implement relevant circuitry to enable a micro-processor to become an integrated part of a mechatronic system *Competencies:* • Are able to design and implement simple, micro-processor-based systems that can be integrated in mechatronic systems and handle fundamental monitoring and control tasks.
Type of instruction:	As described in the introduction to Chapter 3.
Exam format:	Individual oral or written examination.

Evaluation criteria: Stated in the Framework Provisions

Control Engineering
Regulering

Semester:	4th semester
Prerequisites:	Qualifications corresponding to 3rd semester on the bachelor's programme in electronics and computer engineering
Purpose:	Students shall understand fundamental principles of regulation systems as well as real time issues within this kind of systems. Students shall be able to develop a physical regulation system using the classical control techniques and implement the developed digital controller using the programming skills. In order to provide effective control solutions, the students are required to make *models* of the systems as well as consider the effects of *feedback* (the control) and *noise* (the disturbances) in a more rigorous manner than before.

Objectives: Students who complete the module:

Knowledge:

- Must have insight of transfer functions described via the Laplace formulation, including feature analysis, such as poles, zeros, and analog/digital implementation
- Must have an understanding of state space description of modern control systems, including the feature analysis, such as controllability, observability and eigen-structures etc.
- Shall have the insight of different modelling techniques, including the first-principle and experimental approaches
- Must be able to linearize non-linear system models in order to approximate them by linear models
- Must have insight into real-time aspects in relation to digital systems communicating with other analog and/or digital systems
- Must have an understanding of basic power electronics and typical electrical machines, such as different types of motors and generators

Skills:

- Must be able to analyse and select methods for modelling of physical systems, including electric, electro-mechanical, thermal and fluid dynamical systems, at a level where the resulting models can be utilized in a control system design
- Must be able to apply selected theoretical and/or experimental modeling techniques for modeling dynamic systems and simulating them
- Must be able to analyse the open-loop and closed-loop system features and specify system performances, both in transfer function and state space descriptions
- Must be able to apply both classical (frequency-domain) and modern (state space) control techniques for analysis and design of a control system based on a given specification
- Must be able to convert the developed controller into a digital version in order to implement it in a digital programmable device, for example, in a specific micro-processor or PC based manner

Competencies:

- Must be able to apply different modelling techniques to illustrate dynamic system's features and performance, with an orientation for control design purpose
- Must be able to simulate the obtained mathematical model by employing some simulation tools, such as Matlab/Simulink.
- Must be able to analyse, design and implement a control solution for a given specific regulation problem, by using both classical and modern control theories
- Must have insight of basic principles and analysis of power electronics and electrical machines, potentially some control issues of these devices and systems

A control Type of instruction:	Project work with supervision
Exam format:	Oral examination based on a written report
Evaluation criteria:	Stated in the Framework Provisions

Modelling and simulation
Modellering og simulering

Semester:	4th semester
Prerequisites:	Basic electrical engineering
Purpose:	To enable students to apply some of theoretical and experimental modelling methods into their project and simulate the system by means of simulation tools, such as Matlab/Simulink
Objectives:	

Knowledge:

- Must have knowledge of the modelling of some typical physical systems, such as mechatronic systems, flow dynamic systems, energy production/transportation/distribution systems, process systems etc., provision of operating conditions
- Must have insight into the theoretical modelling for dynamic systems, including the principles of mass balance, energy balance and momentum balance
- Must have the knowledge of experimental modelling of linear and non-linear dynamic systems, including the experiment design, data collection and pre-filtering, model structure selection, parameter estimation and model validation
- Must have insight of linearization techniques of nonlinear systems,
- Must be able to simulate the obtained mathematical model in some typical simulation environment, such as Matlab/Simulink

Skills:

- Shall be able to apply basic theoretical and experimental modelling techniques for modelling dynamic systems and simulating them
- Shall be able to model and analyse some typical dynamical systems, including electrical, mechanical, power and thermo dynamical systems etc.
- Must be able to develop models of dynamic systems in the form of block diagrams and be able to reformulate the equivalent diagrams
- Must be able to linearize a obtained nonlinear system and analyse the difference between the linearized and original systems
- Must be able to simulate the obtained mathematical model of concerned system and analyse the system features within a proper simulation environment

Competences:

- Be able to apply the theoretical modelling approach to model some typical physical systems, with an orientation for control design purpose
- Be able to correctly apply the experimental modelling approach for complicated systems, including the proper experiment design, data collation and analysis, selection of model structure and estimation of system parameters, as well as model validation
- Be able to apply Linearization techniques for nonlinear system analysis and simplification

Type of instruction:	As described in the introduction to Chapter 3.
Exam format:	Individual oral or written examination
Evaluation criteria:	Stated in the Framework Provisions

Control Theory
Kontrolteori

Semester:	4^{th} semester
Prerequisites:	Linear algebra, calculus and mathematics basic electrical engineering
Purpose:	To offer students with systematic and fundamental knowledge of feedback control theory, including the classical (transfer function based) and modern (state space based) control methods. After this course, students are able to formulate the control design problem; analyse the open & closed loop systems' features and performances; commit a proper control design by following either classical or modern or both control design methods; implement the designed solution in a digital manner and verify the design through experiment.
Objectives:	Students who complete the module:

Knowledge

- Must have insight of the transfer function description and state space description from a control development point of view
- Must have insight of the system's characteristics with the correlation of system's dynamic and stationary behaviours, including the impact of system type and order, as well as poles and zeros and their influence on the system response
- Must have insight of typical classical control design methods, including the PID tuning, root locus method, and frequency design methods
- Must have an understanding of a system's frequency response characteristics, including open-loop and closed-loop perspectives
- Must be able to commit system's stability analysis and determine the stability margins
- Must have an understanding of fundamental system property analysis based on state space description, i.e., controllability, observability, stability and robustness
- Must have insight into typical modern control design techniques, including full state feedback control, observer design, and observer-based feedback control
- Must have an understanding of basic optimal control methods, such as LQR control.
- Must have insight into implementation of developed controllers

Skills

- Shall be able to analyse the concerned system static and dynamic features based on both transfer function description and state space description
- Shall be able to commit a control problem formulation, analysis, design, implementation and validation based on a concerned regulation problem and system, by using both classical and modern control design methods

- Shall be able to develop and tune a PID type of controller and analyse the consequence to the controlled system
- Shall be able to design a type of feedback controller based on the state space model, and analyse the influence to the open-loop and closed loop systems characteristics
- Shall be able to discuss and implement the developed controller in a correct and reliable digital manner

Competencies

- Must have gained the ability to translate academic knowledge and skills within the fields of basic modelling and control engineering to a practical problem, which can be formulated and solved
- Are able to design a control system, such that the system can be used to solve the problem formulated above
- Possesses the ability to design and implement algorithms for the concerned control problem.

Type of instruction:	As described in the introduction to Chapter 3.
Exam format:	Individual oral or written examination
Evaluation criteria:	Stated in the Framework Provisions

Power Electronics and Networks
Effektelektronik og netværk

Semester:	4th semester
Prerequisites:	Linear algebra, calculus and mathematics, basic electric circuits, AC-circuits and electro physics
Purpose:	To offer students with basic knowledge about power electronics, such as transformers, inverters and converters etc., and fundamental knowledge about electrical machines. Network and data communication is essential part of most systems today so student learns the basics about networks & data communication.

Objectives: Students who complete the module:

Knowledge:

- Have knowledge of components in the area of Power Electronics including diodes, rectifiers, thyristor rectifiers, coils, transformers, capacitors, MOSFETs, bipolar transistors
- Have knowledge of fundamental converter theory including Buck, Boost, Buck-Boost and Forward converter in both Continuous Conduction Mode and Discontinuous Conduction Mode.
- Have knowledge of the principles of Pulse-Width Modulation
- Have knowledge of the transformer idle and load curve including determining parameters through experiments
- Have understanding of the principles and handling of systems characterized by numerous cooperating and communicating processes
- Have knowledge about the comprehension of principles and techniques of modern data network systems and their communications
- Have knowledge of basic embedded sensor networks

Skills:

- Must be able to apply stationary analysis for transformers and converters
- Must be able to choose the right components and converter topology for a given task
- Must be able to perform calculations of conduction losses, design criteria for choice of components
- Must be able to design and build a coil for a given task
- Must be able to understand OSI models and protocol concepts
- Must be able to understand Layer 1 and 2 including basic data-transmission, MAC, LLC, HDLC
- Must be able to understand network protocols and their programming, including IP, UDP, TCP, Sockets, and RPC.
- Must be able to use concepts from the OSI model, including the MAC, network, transport and application layers.

- Must be able to use TCP / IP protocol stack and be able to assess functions in the network, transport and application layers, including Quality of Service mechanisms.
- Must be able to understand and use network topologies for embedded sensor networks including SPI and I2C

Competencies:

- Must be able handle development orientated situations in relation to stationary conditions for converters
- Shall independently be able to engage in disciplinary and interdisciplinary corporations with a professional approach within converter design
- Shall be able to analyse describe/design a communication network for a given system.
- Shall be able to choose the right communication network topology fir accessing various types of sensors for a given task

Type of instruction:	As described in the introduction to Chapter 3.
Exam format:	Individual oral examination based on a written report
Evaluation criteria:	Stated in the Framework Provisions

Automation
Automation

Semester: 5^{th} semester

Prerequisites: Qualifications corresponding to 4th semester on the bachelor's programme in electronics and computer engineering

Purpose: This semester offers two themes: automation and real-time signal processing, students has the option to select any one of them. Through the automation theme student shall acquire fundamental knowledge of digital regulation systems as well as the real time issues within these kinds of systems. Students shall be able to develop a physical regulation system using the control techniques leaned from previous semester. They should be able to implement the developed digital controller using the real-time and embedded programming skills.

Objectives: Students completing this project module should have:

Knowledge:

- Must have insight of sampling mechanism and sampling theorem for an ADC implementation
- Must have insight of typical numerical computation methods, including the principles, features and limitations
- Must be able to simulate the concerned digital control solution in an efficient and reliable manner
- Must be able to convert a controller initially formulated in an analog form to its equivalent digital version and analyse the influence because of this discretization
- Must have insight of typical digital filter design techniques, including FIR and IIR filters
- Must have insight of discrete Fourier transform and its efficient digital computation algorithms, FFT
- Must be able to deal with real-time issues in a systematic manner when a digital controller is implemented

Skills:

- Must be able to determine a correct sampling frequency based on the system frequency feature analysis
- Must be able to commit a proper discretization of a controller which initially is in analog form
- Must be able to perform spectrum analysis of the signals
- Must be able to handle the real-time issues of digital implementation in a professional manner

Competencies:

- Must be able to analyse and design a digital system controller in a professional way
- Must be able to design typical frequency selective filters both as direct digital as well as in an indirect manner

- Must be able to perform the real-time analysis and programming of the designed digital controller

Type of instruction:	Project work with supervision
Exam format:	Oral examination based on a written report
Evaluation criteria:	Stated in the Framework Provisions

Digital Filtering
Digital filtrering

Semester:	5th semester
Prerequisites:	Qualifications corresponding to 4th semester on the bachelor's programme in electronics and computer engineering
Purpose:	This semester offers two themes: automation and real-time signal processing, students has the option to select any one of them. The purpose of real-time signal processing is to offer students with fundamental knowledge of digital signal processing systems as well as the real time issues within this kind of systems. Students shall be able to develop a signal processing system using the knowledge leaned from this semester, and implement the developed solution using the real-time ad embedded programming skills.
Objectives:	Students who complete the project module:

Knowledge:

- Must have insight of sampling mechanism and sampling theorem with proper ADC implementation
- Must have insight of typical numerical computation methods, including the principles, features and limitations
- Must be able to simulated the concerned digital signal processing solution in an efficient and reliable manner
- Must be able to convert an analog filter into its equivalent digital version, and analyse the influence due to this discretization
- Must have insight of typical digital filter design techniques, including FIR and IIR filter designs
- Must have insight of discrete Fourier transform and its efficient digital computation algorithms, named FFT
- Must have an understanding of different digital filter, e.g., DSP implementation
- Must be able to take care of the real-time issue in a systematic manner when a digital filter is implemented

Skills:

- Must be able to determine a correct sampling frequency based on system frequency feature analysis
- Must be able to commit a proper discretization of an analog filter
- Must be able to design frequency selective filters and analyse the system frequency features
- Must be able to commit digital signal spectrum analysis and analyse its results and limitations
- Must be able to cope with the real-time issue of digital implementation in an professional manner

Competencies:

- Must be able to analyse and design a digital implementation of a filter in an professional way

- Must be able to design typical frequency selective filters either in a direct digital way or indirect way, i.e., converting from analog one to its digital formulation
- Must be able to produce a signal's digital spectrum and retrieve signal's corresponding features
- Must be able to commit the real-time analysis and programming of the concerned digital filter

Type of instruction:	Project work with supervision
Exam format:	Oral examination based on a written report
Evaluation criteria:	Stated in the Framework Provisions

Numerical methods
Numeriske metoder

Semester: 5th semester
Prerequisites: Mathematics
Purpose: Not all mathematical and engineering problems are simple enough to solve analytically. The purpose of this course is to provide the students with tools and methodologies to approach those problems that cannot be solved with 'pen and paper', but requires numerical approximations.

Objectives: Students who complete the module:

Knowledge:

- Must have understanding of how to solve partial differential equations with analytic methods
- Must have understanding of different numerical methods
- Must have an understanding of finite difference, finite volume and finite element method

Skills:

- Shall be able to use analytical methods for solving partial differential equations, in particular the method of Separation of Variables and D'Alembert's Principle.
- Shall be able to utilize numerical methods to solve mathematical problems, including:
  - Systems of linear equations, Gauss elimination, and factorization-based method.
  - Iterative solution of systems of linear equations, e.g., Gauss-Seidel.
  - Ill-conditioned systems of linear equations.
  - Matrix Eigen value problems.
  - Solving systems of non-linear equations.
  - Interpolation and splines.
  - Numerical solution of definite integrals.
  - Numerical solution of first- and second-order differential equations.
- Must be able to utilize finite difference methods for solution of partial differential equations, including:
  - Approximation by finite differences.
  - Elliptical equations.
  - Dirichlet and Neumann boundary value problems.
  - Parabolic equations.
  - Explicit and implicit method, the Theta-method.
  - Hyperbolic equations.
  - Relationship with finite volume methods.
- Shall have understanding of finite element methods for solving partial differential equations.

Competencies:

- Shall demonstrate development of his/her knowledge of, understanding of, and ability to make use of, mathematical theories and methods related to solving technical problems using numerical methods.

- Shall be able to identify their own learning requirements and structure their own learning within the context of numerical mathematics.

Type of instruction:	As described in the introduction to Chapter 3.
Exam format:	Individual oral or written examination
Evaluation criteria:	Stated in the Framework Provisions

Signal Processing
Signalbehandling

Semester: 5th semester

Prerequisites: Mathematics, micro processors and programming, fundamental control theory and modelling

Purpose: To offer students with fundamental knowledge about analysis, design and implementation of digital systems, including digital controllers or filters.

Objectives: Students who complete the course:

Knowledge:

- Must have the knowledge of Z-transform and its application in analysis and design of digital signals and systems
- Must have knowledge about sampling theories and methods for processing of physical signals on a computer
- Must have knowledge about theories and methods for spectral estimation
- Must have knowledge about theories and methods for design of digital filters (IIR/FIR)
- Must be able to implement IIR filters using bilinear transforms and impulse invariant methods
- Must have an understanding of the limitations of taught theories and methods
- Must have knowledge about the interplay between analysis of signals in the time and frequency domains
- Must have knowledge about basic implementation structures and specific DSP implementation

Skills:

- Shall be able to utilize some software tools for analysis, design and simulation of digital signal processing systems
- Must be able to apply theories and methods for spectral estimation including DFT / FFT
- Must be able to demonstrate the correlation between frequency resolution, window functions and zero-padding
- Must be able to apply theories and methods for design of digital filters
- Must be able to design FIR filters using windowing methods
- Must be able to explain the relationship between the pole/zero plots and frequency responses of digital filters
- Must be able to implement filters in practice, making use of appropriate filter structures, quantization, and scaling.

Competencies:

- Shall be able to discuss fundamental theories and methods for analysis and processing of digital signals, using correct terminology
- Shall be able to assess opportunities and limitations in connection with practical application of taught theories and methods

Type of instruction:	As described in the introduction to Chapter 3.
Exam format:	Individual oral or written examination
Evaluation criteria:	Stated in the Framework Provisions

Real-time Embedded Systems
Indlejrede realtidssystemer

Semester:	5th semester
Prerequisites:	Micro-processor and programing
Purpose:	To give the students at an application level to construct a real time embedded system.
Objectives:	To enable students at an application level to gain knowledge to make analysis, design and implementation of real time embedded systems.

Knowledge

- Must have knowledge and understanding real time embedded systems
- Must have knowledge of programming concepts and embedded programming
- Must have knowledge the software engineering practices in the embedded software development
- Must have knowledge of real time operating systems
- Must have knowledge of hardware and software co design for a real time embedded system
- Must have knowledge of processors for embedded systems
- Must have knowledge of scheduling and guaranties on deadlines

Skills

- Must be able to make analysis of real time including embedded systems
- Must be able to design and develop an embedded systems
- Must be able program and test a real time embedded system
- Must be able to understand and analyse various embedded systems
- Must be able to understand and analyse scheduling and guaranties on deadlines for embedded systems

Competencies

- Must be able to handle real time embedded systems and laboratory setups in study- or work-related contexts
- Must be able to independently engage in professional and interdisciplinary collaboration with a professional approach within the context of real time embedded systems
- Must be able to identify his/her own learning needs within the real time systems including the embedded systems and structure such learning accordingly.

Type of instruction:	As described in the introduction to Chapter 3.
Exam format:	Individual oral or written examination
Evaluation criteria:	Stated in the Framework Provisions

BSc Project (Automation and Control)
BSc projekt (Automation og regulering)

Semester: 6th semester

Prerequisites: Knowledge, skills and competencies equivalent to having passed the 5th semester

Purpose: The project must be based on a physical process. The process can be mechanical, thermal, electrical, biologic or chemical. A dynamic model of the process has to be developed. The model has to be adjusted and verified through measurements. Demands as well in the time as in the frequency domain has to be listed. Using the dynamic model a classic and/or a state space controller are designed and implemented on the process. The controllers have to be evaluated and compared to the demands.

Objectives: Students who complete the project module:

Knowledge:

- Must have knowledge of how to design and analyse control systems
- Must be able to understand and implement dynamic modelling,
- The control design should follow up with the model-base approaches, i.e., either classic or modern controller design.
- Must be able to implement the designed controller in its equivalent digital format, and be able to analyse this discretization influence

Skills:

- Must be able to analyse dynamic systems in time and frequency domain
- Must be able to analyse and apply model based controller design methods, including classical and modern methods
- Must be able to apply theoretical and experimental modelling principles for mechanical, thermodynamic, biological or chemical systems to develop their corresponding dynamic model with the orientation for control design purpose
- Must be able to analyse and apply numerical methods for simulating dynamic systems
- Must be able to evaluate industrial control and supervision methods.
- Must be able to communicate the above knowledge and skills (using proper terminology of the field), both orally and in a written report

Competencies:

- Shall be equipped with all necessary knowledge to be qualified as a control engineer
- Must be able to select and extract relevant features and apply these in a new context

- Must be able to plan, structure and execute a project, within the subject-field of this project module

Type of instruction:	Project work with supervision
Exam format:	Oral examination based on a written report
Evaluation criteria:	Stated in the Framework Provisions

BSc Project (Embedded Real-Time Signal Processing)
BSc projekt (Indlejret realtidssignalbehandling)

Semester: 6th semester

Prerequisites: Real time embedded system

Purpose: An embedded system is defined as an electronic system which is based on a computer, but the system is not in itself a computer, e.g., like a PC. The purpose of this project module is to specify, design, simulate, implement, test and document (part of) an embedded real-time signal processing system. In this context, the algorithm(s) which are to perform the signal processing have to be developed, simulated/evaluated (preferably using C or Matlab) and optimized. The overall design parameters may include, but are not limited to execution time, code size, numerical robustness, and eventually energy consumption. Primarily, the project will focus on the signal processing theories and algorithms, as well as the development of optimal source- and object codes using commercially available development boards/tools, thus excluding the design and implementation of user-specific hardware.

Objectives: Students who complete the project module:

Knowledge:

- Must have knowledge about the building blocks used in a generic embedded real-time digital signal processing system, their mutual interaction and interfaces, as well as relevant performance parameters.
- Must have knowledge about theories and methods used to design numerically robust and resource optimal signal processing algorithms suitable for being executed in real-time on a given hardware.

Skills:

- Must be able to analyse a technical problem which naturally finds its solution in terms of real-time digital signal processing. Secondly, to formulate a set of specifications for the algorithms to be developed, and possibly also for the hardware/software platform to be used.
- Must be able to apply various methods to design, simulate, and evaluate digital signal processing algorithms according to the specifications.
- Must be able to analyse digital signal processing algorithms from a computational complexity, structural, and data flow oriented point of view in order to specify architectural requirements for a software programmable target platform.
- Must be able to apply design tools, such as C compilers (possibly using in-line assembly language), in order to develop and optimize real-time executable code for digital signal processing algorithms.
- Must be able to evaluate 1) an overall system solution, and 2) the design methods applied to derive the solution. This must be done in terms of relevant metrics such as execution time, memory usage and energy consumption. Secondly, from a micro-

computer architectural point of view, the students must be able to evaluate the match between algorithms and architectures.

- Must be able to communicate the above mentioned knowledge and skills (using the terminology of the domain), both orally and in a written report.

Competencies:

- Must be able to identify, design, implement, and evaluate a viable solution for an embedded real-time signal processing system.
- Must be able to plan, structure, and conduct a project within the scientific subject of this project module.

Type of instruction:	Project work with supervision
Exam format:	Oral examination based on a written report
Evaluation criteria:	Stated in the Framework Provisions

Introduction to Probability Theory and Statistics
Introduktion til sandsynlighedsregning og statistik

Semester:	6th semester
Prerequisites:	Fundamentals in linear algebra, calculus, and Fourier theory
Purpose:	After attending the course the students have developed the engineering intuition of the fundamental concepts and results of probability, and statistics. They are able to apply the taught material to model and solve simple engineering problems involving randomness.

Objectives: Students who complete the course:

Knowledge:

- Must have knowledge about the concept of probability spaces
- Must have knowledge about the conceptual models of estimation and hypothesis testing
- Must be able to understand the basic concepts of probability theory, i.e., probability of events, random variables, etc.
- Must be able to understand basic concepts of statistics such as binary hypothesis testing.

Skills:

- Must be able to apply/compute
  - Bayes rule in simple contexts
  - The probability that Binomial, Poisson, and Gaussian random variables take values in a specified interval
  - The mean and variance of Binomial, Poisson, and Gaussian random variables
  - The marginal distributions of multi-variate Gaussian variables
- Must be able to apply and interpret
  - ML-estimation in simple contexts involving the Binomial, Poisson, and Gaussian distribution
  - Binary-hypothesis tests in simple contexts involving the Binomial, Poisson, and Gaussian distribution

Competencies:

- Must be able to apply the general concepts of probability theory and statistics in a new, simple context. This includes choosing suitable methods, evaluating outcomes, and drawing the appropriate conclusions

Type of instruction:	As described in the introduction to Chapter 3.
Exam format:	Individual oral or written examination
Evaluation criteria:	Stated in the Framework Provisions

Matrix Computation and Convex Optimization
Matrix beregninger og Convex optimering

Semester: 6th semester
Prerequisites: Linear algebra, calculus
Purpose: Engineering systems and design problems can often be compactly described analysed and manipulated using matrices and vectors. Moreover, tractable solutions to design problems can be obtained by casting the design problems as optimization problems. For the class of linear and quadratic problems, the solutions can be obtained by solving systems of equations. In computer programs, this is achieved via matrix factorizations. For the larger class of convex problems, no closed-form solution may exist and numerical methods must be applied. This course aims at teaching numerically robust methods for solving systems of equations and, more generally, convex optimization problems, including also standard constrained problems.

Objectives: Students who complete the course:

Knowledge:

- Must have knowledge about convex functions and sets, norms, special matrices
- Must have understanding of how to classify and solve systems of equations and convex optimization problems
- Must have understanding of numerical aspects of solving systems of equations and convex optimization problems
- Must have knowledge about Lagrange multipliers
- Must have understanding of matrix factorizations and their properties

Skills:

- Must be able to identify optimization problems and cast them into standard form
- Must be able to identify types of extrema (minima, maxima, local, global, etc.)
- Must be able to apply Eigen value and singular value decomposition to relevant matrix problems
- Must have understanding of state space descriptions of systems of linear differential equations
- Shall be able to apply numerically robust methods to solve systems of equations
- Shall be able to apply and implement the following numerical optimization methods to unconstrained optimization problems: Steepest Descent, Newton's method, Gauss-Newton method
- Shall be able to apply and interpret least-squares solutions when solving over-determined systems of equations
- Shall be able to apply the Lagrange multiplier method to constrained convex optimization problems

Competencies:

- Are able to apply linear algebra theory to analyse engineering

	systems in their field • Can state and analyse engineering design problems in their field as systems of equations or standard optimization problems • Are able to select appropriate matrix factorization or numerical optimization methods to solve engineering design problems in their field
Type of instruction:	As described in the introduction to Chapter 3.
Exam format:	Individual oral or written examination
Evaluation criteria:	Stated in the Framework Provisions

Chapter 4: Entry into Force, Interim Provisions and Revision

The curriculum is approved by the Dean of the Faculty of Engineering and Science and enters into forces as of 1 September 2014.

Students who wish to complete their studies under the previous curriculum from 2011 must conclude their education by the summer examination period 2016 at the latest, since examinations under the previous curriculum are not offered after this time.

In accordance with the Framework Provisions for the Faculty of Engineering and Science and The Faculty of Medicine at Aalborg University, the curriculum must be revised no later than 5 years after its entry into force.

Chapter 5: Other Provisions

5.1 Rules concerning written work, including the Bachelor's project

In the assessment of all written work, regardless of the language it is written in, weight is also given to the student's formulation and spelling 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 Bachelor's project must include an English summary.[1] If the project is written in English, the summary must be in Danish.[2] The summary must be at least 1 page and not more than 2 pages (this is not included in any fixed minimum and maximum number of pages per student). 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

In the individual case, 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 Framework Provisions for the rules on credit transfer.

5.3 Rules concerning the progress of the Bachelor's programme

The student must participate in all first year examinations by the end of the first year of study in the Bachelor's programme, in order to be able to continue the programme. The first year of study must be passed by the end of the second year of study, in order that the student can continue his/her Bachelor's programme.

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[1] Or another foreign language (French, Spanish or German) upon approval by the Board of Studies.
[2] The Board of Studies can grant exemption from this.

In special cases, however, there may be exemption from the above if the student has been on a leave of absence. Leave is granted during first year of study only in the event of maternity, adoption, military service, UN service or where there are exceptional circumstances.

5.4 Rules concerning the completion of the Bachelor's programme
The Bachelor's programme must be completed no later than six years after it was begun.

5.5 Special project process
In the 3rd, 4th and 5th semesters, the student can upon application, design an educational programme where the project work is replaced by other study activities; cf. the Framework Provisions section 9.3.1.

5.6 Rules for examinations
The rules for examinations are stated in the Examination Policies and Procedures published by the Faculty of Engineering and Science on their website.

5.7 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.

5.8 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.

5.9 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.

Version 2 September 2017: Geoscience A has been added in 2.1 (admission).