AALBORG UNIVERSITET

STUDIEORDNING FOR KANDIDATUDDANNELSEN I AVANCERET EFFEKTELEKTRONIK, 2023

CIVILINGENIØR
ESBJERG

MODULER SOM INDGÅR I STUDIEORDNINGEN

INDHOLDSFORTEGNELSE

DIAGNOSIS AND MAINTENANCE

2024/2025

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Have knowledge and comprehension for how to design condition monitoring and diagnostic for power electronics or dynamic systems
- Have knowledge and comprehension within different system identification and diagnostic methods
- Have knowledge and comprehension within the design, analysis and modelling of power electronic systems or sub-systems with complex dynamics and elements with linear and non-linear behaviour using digital platforms
- Have knowledge and comprehension within maintenance schemes, economic benefits, scope and limitation
- Have knowledge and comprehension within maintenance strategies applied to various problems in the industrial sectors

SKILLS

- Be able to judge the usefulness of the different scientific methods for the design of diagnostic, and condition monitoring systems
- Be able to verify the different scientific analysis and methods combined with laboratory experiments or real measured data series

COMPETENCES

- Be able to control the working and development process within the project theme, and be able to develop new solutions within diagnostic, condition monitoring, and maintenance of energy systems
- Be able to set up innovative ideas within the area of condition monitoring, diagnostic and maintenance
- Independently be able to continue own development in competence and specialisation related to the field

TYPE OF INSTRUCTION

Problem based project organised project work in groups.

The project can be a disciplinary project, a cross disciplinary project or a part of a multi-disciplinary project, where several groups from the department do different parts of a larger project. Finally, the project can also be a part of a so-called MEGA project, where several project groups from more departments are participating, each doing their part of the large project to find a total solution.

Project work including supervision may be supplemented with lectures, workshops, presentation seminars, consultant meetings regarding PBL content, laboratory tests, etc.

The project work is split in two periods:

- P0 period for problem definition, and
- P1 period for definition of methodology for solving the problem and implementation of the methodology

The P0 period lasts about 5-6 weeks starting at the beginning of the semester. The work in the P0 period includes a problem analysis and a problem formulation for the subject to be dealt with in the P1 period of the project. The problem analysis and problem formulation is written in a P0 document including also a process analysis for the P0 period. The P0 document is presented in a P0 status and presentation seminar, where the submitted documents for the P0 period are discussed.

The considered system should be analysed, and models and simulations of the system are to be made. Different methods are to be applied to find the parameters of the system.

The set-up models should be verified by experimental test either directly on a real system or on a model or parts of the scaled systems set-up in the laboratory.

The project work must be documented in a scientific way by a summary report, a paper and a poster as described under "Additional Information".

The summary report should include both the problem analysis, problem formulation, methodology and implementation as it would be in the case of a standard project report.

EXTENT AND EXPECTED WORKLOAD

Since it is a 15 ECTS project module, the work load is expected to be 450 hours for the student.

EXAM

PREREQUISITE FOR ENROLLMENT FOR THE EXAM

- It is a precondition that students participate in the Conference for MSc Energy Students (CES). Students are required to prepare a scientific paper and a poster which must be presented at the conference.
- In case of a re-exam, the student will have to present the scientific paper and poster in front of a committee made up of the supervisor and at least one internal adjudicator.

EXAMS

Name of exam	Diagnosis and Maintenance
Type of exam	Oral exam based on a project The project group should orally present the project work and scientific paper as specified in the Examination Policies and Procedures. The project group members will undergo an oral examination with internal adjudicator, based on the scientific paper, poster and the project summary report.
ECTS	15
Assessment	7-point grading scale
Type of grading	Internal examination
Criteria of assessment	The criteria of assessment are stated in the Examination Policies and Procedures

ADDITIONAL INFORMATION

Examination format

The exam will be based on the documentation submitted and the rules in "Guidance for the Project of 1st Semester MSc in Advanced Power Electronics", see below.

Guidance for the Project of 1st Semester MSc in Advanced Power Electronics

1. Demands to the project documentation

The project should fulfil the objectives of the 1st semester project theme and should be documented to an acceptable technical and scientific level. The documentation shall include a scientific paper and a poster, which shall fulfil the standard for an international conference, e.g. the IEEE specifications. Moreover, the documentation shall include a project summary report - see below.

2. Project documentation
The following material must be uploaded to the system “Digital Exam” on the date given for the submission:

- Scientific paper, max. 10 pages, which presents the primary content and results of the project work
- Project summary report (see below)
- Project poster

3. Conference participation
The paper must be presented, by one or more group members at a conference arranged within the Department of Energy. The conference will be run in the same manner as an international conference. The project poster must also be presented at this conference. All group members must attend the conference and the poster session to be allowed to participate in the project examination.

4. Project summary report
The project summary report should elaborate the project details and conclusions. The maximum length of the summary report (report without appendices) is 50 pages. For more information see semester description in Moodle.

5. Project exam
The project evaluation will take place at a later date than the conference.

At the project examination the project group shall present its project work in accordance to the Examination Policies and Procedures.

The presentation and assessment of the project is conducted in English.

FACTS ABOUT THE MODULE

Danish title	Diagnosticering og vedligehold
Module code	E-APEL-K1-1C
Module type	Project
Duration	1 semester
Semester	Autumn
ECTS	15
Language of instruction	English
Empty-place Scheme	Yes
Location of the lecture	Campus Esbjerg
Responsible for the module	Amin Hajizadeh

ORGANISATION

Education owner	Master of Science (MSc) in Engineering (Advanced Power Electronics)
Study Board	Study Board of Build, Energy, Electronics and Mechanics in Esbjerg
Department	Department of Energy
Faculty	The Faculty of Engineering and Science

CONDITION MONITORING AND PRODUCT LIFE CYCLE MANAGEMENT

2024/2025

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Have comprehension of the benefits of preventive and predictive maintenance and condition monitoring in the industrial sector
- Have comprehension on the modern data driven approaches in condition monitoring
- Have comprehension of the concept of product data and Project Lifecycle Management (PLM) fundamentals
- Have comprehension of the use of databases and common data formats to manage, store and process data

SKILLS

- Be able to analyse data for vibrational machinery condition monitoring and fundamental of effects of vibration. Measuring equipment includes sensors, signal conditioners, and recording elements
- Be able to analyse typical case studies, and identifications of malfunctions
- Be able to implement data driven modelling for condition monitoring and anomaly detection
- Be able to assess the performance of data driven models for condition monitoring

COMPETENCES

- Be able to monitor the condition and develop measurable preventive maintenance for given service industry problems
- Be able to monitor machinery condition with vibration effects using various electronic equipment and scaled engineering approach
- Be able to compare modern data driven models and algorithms for condition monitoring
- Be able to apply a data driven approach to analyse and implement condition monitoring methods

TYPE OF INSTRUCTION

The course module will be targeted with a mixture of lectures, self-preparatory presentation by students, and discussion on various real time case studies supplemented with e-learning activities.

EXTENT AND EXPECTED WORKLOAD

Since it is a 5 ECTS course module, the work load is expected to be 150 hours for the student.

EXAM

EXAMS

Name of exam	Condition Monitoring and Product Life Cycle Management
Type of exam	Written or oral exam
ECTS	5
Assessment	7-point grading scale
Type of grading	Internal examination

Criteria of assessment	The criteria of assessment are stated in the Examination Policies and Procedures

FACTS ABOUT THE MODULE

Danish title	Tilstandsovervågning og livscyklus styring for produkter
Module code	E-APEL-K1-3B
Module type	Course
Duration	1 semester
Semester	Autumn
ECTS	5
Language of instruction	English
Empty-place Scheme	Yes
Location of the lecture	Campus Esbjerg
Responsible for the module	Daniel Ortiz Arroyo, Petar Durdevic

ORGANISATION

Education owner	Master of Science (MSc) in Engineering (Advanced Power Electronics)
Study Board	Study Board of Build, Energy, Electronics and Mechanics in Esbjerg
Department	Department of Energy
Faculty	The Faculty of Engineering and Science

PROBABILITY THEORY, STOCHASTIC PROCESSES AND APPLIED STATISTICS

2024/2025

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Have knowledge about fundamental concepts in probability, including conditional probability and independence
- Have knowledge about discrete and continuous random variables and relevant properties of these
- Have knowledge about various examples of descriptive statistics and graphics, e.g. histograms, boxplots, scatterplots, lag plots and auto covariance plots
- Have knowledge about statistical inference, including estimation, confidence intervals and hypothesis testing
- Have knowledge about basic concepts related to stochastic processes such as stationarity, correlation function and spectral density
- Have elementary knowledge about wiener processes, white noise and linear stochastic differential equations
- Have comprehension of a concrete example of a model for a simple stochastic process

SKILLS

- Be able, given specific data, to specify a relevant statistical model and account for the assumptions and limitations of the chosen model
- Be able to use relevant software for carrying out the statistical analysis of given data and be able to interpret the results of the analysis
- Be able to use statistical models, like linear regression (simple and multiple) and analysis of variance

COMPETENCES

- Be able to judge the applicability of statistics within own area
- Be capable of performing a critical evaluation of the results of a statistical analysis
- Be capable of communicating the results of a statistical analysis to people with no or little background within statistics.

TYPE OF INSTRUCTION

Lectures in combination with practical exercises and self-study, e-learning or similar.

EXTENT AND EXPECTED WORKLOAD

Since it is a 5 ECTS course module, the work load is expected to be 150 hours for the student.

EXAM

EXAMS

Name of exam	Probability Theory, Stochastic Processes and Applied Statistics
Type of exam	Written or oral exam
ECTS	5
Permitted aids	Der henvises til den pågældende semesterbeskrivelse/modulbeskrivelse
Assessment	7-point grading scale

Type of grading	Internal examination
Criteria of assessment	The criteria of assessment are stated in the Examination Policies and Procedures

FACTS ABOUT THE MODULE

Danish title	Sandsynlighedsregning, stokastiske processer og anvendt statistik
Module code	22KMATSPASTA
Module type	Course
Duration	1 semester
Semester	Autumn
ECTS	5
Language of instruction	English
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg, Campus Esbjerg
Responsible for the module	Ege Rubak

ORGANISATION

Study Board	Study Board of Mathematical Sciences
Department	Department of Mathematical Sciences
Faculty	The Faculty of Engineering and Science

SYSTEM IDENTIFICATION AND DIAGNOSIS

2024/2025

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Have comprehension of the fundamental principles of typical methods of system identification
- Have comprehension of the fundamental concepts, terms and methodologies of abnormal diagnosis
- Have comprehension of some typical model-based and signal-based diagnosis

SKILLS

- Be able to apply the learned knowledge to handle some simple system identification problems under assistance of a commercial software
- Be able to apply and analyse different diagnosis methods

COMPETENCES

- Independently be able to define and analyse scientific problems within the area of system identification and diagnosis
- Independently be able to be a part of professional and interdisciplinary development work within the area of system identification and diagnosis

TYPE OF INSTRUCTION

The course is taught by a mixture of lectures, workshops, exercises, mini-projects and self-studies, including e-learning activities.

EXTENT AND EXPECTED WORKLOAD

Since it is a 5 ECTS course module, the work load is expected to be 150 hours for the student.

EXAM

EXAMS

Name of exam	System Identification and Diagnosis
Type of exam	Oral exam
ECTS	5
Permitted aids	With certain aids: For more information about permitted aids, please visit the course description in Moodle.
Assessment	7-point grading scale
Type of grading	Internal examination
Criteria of assessment	The criteria of assessment are stated in the Examination Policies and Procedures

FACTS ABOUT THE MODULE

Danish title	Systemidentifikation og diagnosticering
Module code	E-SEE-K1-3A
Module type	Course
Duration	1 semester
Semester	Autumn
ECTS	5
Language of instruction	English
Empty-place Scheme	Yes
Location of the lecture	Campus Esbjerg, Campus Aalborg
Responsible for the module	Matthias Mandø

ORGANISATION

Study Board	Study Board of Build, Energy, Electronics and Mechanics in Esbjerg
Department	Department of Energy
Faculty	The Faculty of Engineering and Science

CONTROL OF POWER ELECTRONIC SYSTEMS

2024/2025

RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

The module is based on knowledge achieved in Power electronics, Electrical machines and Modern digital control.

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Have knowledge about modelling, analysing and simulating a system that must include a power electronic converter, a power source and an application, typically an AC electrical machine or an AC grid
- Comprehension of the practical implementation and test of the designed digital controller for the selected system

SKILLS

- Be able to apply a systematic design procedure for selection of a digital controller for the analysed system in order to meet certain performance requirements
- Be able to verify the analysis and models by means of laboratory experiments or by using real measured data series
- Have an innovative and entrepreneurial behavior giving value for the developed system/apparatus

COMPETENCES

- Be able to control the working and development process within the project theme, and be able to develop new solutions within control in power electronic systems
- Independently be able to define and analyse scientific problems in the area of control of power electronic systems, and based on that make and state the reasons for decisions made for instance with respect to their influences on the total system
- Independently be able to continue own development in competence and specialisation

TYPE OF INSTRUCTION

Problem based project organised work in groups. The project can be a disciplinary project, a cross disciplinary project or a part of a multi-disciplinary project, where several groups from the department do different parts of a larger project. Finally, the project can also be a part of a so-called MEGA project where several project groups from more departments are participating, each doing their part of the large project to find a total solution.

The project must include a power electronic converter, a power source and an application, typically an AC electrical machine or an AC grid. The operating principles for the system must be described and a control problem is formulated, including key specifications.

A dynamic simulation model is made taking the relevant dynamics into account. Different digital control methods are designed, analysed and evaluated by means of the simulation model. At least one method is selected for practical implementation in a real system incorporating a power electronic converter, a power source and a load, and a real□ time digital control system based on a digital signal processor or a micro controller.

The whole system is tested and the developed control strategies are evaluated.

A workshop “PBL competence profile” to make an individual PBL competence profile is offered during the semester. More information can be found at www.ucpbl.net/education-courses/.

EXTENT AND EXPECTED WORKLOAD

Since it is a 15 ECTS project module, the work load is expected to be 450 hours for the student

EXAM

EXAMS

Name of exam	Control of Power Electronic Systems
Type of exam	Oral exam based on a project
ECTS	15
Permitted aids	With certain aids: For more information about permitted aids, please visit the course description in Moodle.
Assessment	7-point grading scale
Type of grading	External examination
Criteria of assessment	The criteria of assessment are stated in the Examination Policies and Procedures

FACTS ABOUT THE MODULE

Danish title	Styring af effektelektroniske systemer
Module code	N-APEL-K2-1A
Module type	Project
Duration	1 semester
Semester	Spring
ECTS	15
Language of instruction	English
Location of the lecture	Campus Esbjerg
Responsible for the module	Matthias Mandø

ORGANISATION

Education owner	Master of Science (MSc) in Engineering (Advanced Power Electronics)
Study Board	Study Board of Build, Energy, Electronics and Mechanics in Esbjerg
Department	Department of Energy
Faculty	The Faculty of Engineering and Science

DYNAMIC MODELLING OF ELECTRICAL MACHINES AND CONTROL SYSTEMS

2024/2025

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Be able to comprehend dynamic models of the transformer, DC Motor, the synchronous machine and the induction machine
- Have knowledge about the limitations for a dynamic model of an electrical machine
- Control principles of DC motors
- Have knowledge about AC machines and space vectors
- Comprehension of techniques for scalar variable-speed control of induction machines
- Knowledge about implementation of different controllers for variable-speed AC-drives
- Knowledge about basic non-linear control theory and its application of electrical machine drives using digital tools

SKILLS

- Independently be able to define and analyse scientific problems involving a dynamic model of an electrical machine
- Be able to analyse and design scalar and vector controllers for electrical drives
- Be able to apply selected linear and non-linear control methods for electrical drives

COMPETENCES

- Independently be able to define and analyse scientific problems involving a dynamic model of an electrical machine using digital platforms
- Be able to implement and design scalar and vector controllers for electrical drives
- Be able to implement selected linear and non-linear control methods for electrical drives

TYPE OF INSTRUCTION

The course will be taught by a mixture of lectures, workshops, exercises, mini-projects, self-study and e-learning.

EXTENT AND EXPECTED WORKLOAD

Since it is a 5 ECTS course module, the work load is expected to be 150 hours for the student

EXAM

EXAMS

Name of exam	Dynamic Modelling of Electrical Machines and Control Systems
Type of exam	Oral exam based on a project
ECTS	5
Permitted aids	With certain aids: For more information about permitted aids, please visit the course description in Moodle.
Assessment	7-point grading scale

Type of grading	Internal examination
Criteria of assessment	The criteria of assessment are stated in the Examination Policies and Procedures

FACTS ABOUT THE MODULE

Danish title	Dynamiske modeller for elektriske maskiner og regulering
Module code	E-SEE-K2-7B
Module type	Course
Duration	1 semester
Semester	Spring
ECTS	5
Language of instruction	English
Empty-place Scheme	Yes
Location of the lecture	Campus Esbjerg
Responsible for the module	Matthias Mandø

ORGANISATION

Study Board	Study Board of Build, Energy, Electronics and Mechanics in Esbjerg
Department	Department of Energy
Faculty	The Faculty of Engineering and Science

ADVANCED POWER ELECTRONICS AND APPLICATIONS

2024/2025

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

The module is based on knowledge achieved in Dynamic modelling of electrical machines and control systems and High voltage engineering and EMI/EMC.

LEARNING OBJECTIVES

KNOWLEDGE

Have knowledge and comprehension within the following areas

- Magnetics scalability toward high power

- - High power three phase transformers
- - High power inductors
- - Material properties

- High power devices

- IGCT, GTO, Thyristor (Press-pack)
- IGBT (package)
- Emerging devices
- Package properties

- High-power converters

- Graetz bridge, Two level and three level (NPC)
- Overview of other multilevel converter topology and basic control and applications.
- Modular multilevel converters
- High Voltage DC transmission and STATCOM

- High Power DC-DC converters

- Soft switching, resonant
- Converter topologies (practical aspects of design)

SKILLS

- Be able to compute the overall size and then system level ratings of the high power converters for different applications in power and renewable energy systems
- Be able to analyse the main components and requirements of high power converters
- Be able to evaluate the converter characteristics and design its high level controller
- Be able to analyse and evaluate high power converter systems and evaluate their pros and cons for the given application
- Be able to evaluate the limitations and hence create the necessary design modifications (at system level) in high power converters

COMPETENCES

- Independently be able to define and analyse high power converter topologies and their specifications for the specific application in power and renewable energy systems
- Independently simulate the high power converter systems and communicate the results for system engineering
- Independently participate in the professional and interdisciplinary development work related with the application of high power converters in power and renewable energy systems

TYPE OF INSTRUCTION

Lecture followed by numerical and simulation exercises and possible e-learning activities.

EXTENT AND EXPECTED WORKLOAD

Since it is a 5 ECTS course module, the work load is expected to be 150 hours for the student.

EXAM

EXAMS

Name of exam	Advanced Power Electronics and Applications
Type of exam	Oral exam
ECTS	5
Permitted aids	With certain aids: For more information about permitted aids, please visit the course description in Moodle.
Assessment	7-point grading scale
Type of grading	Internal examination
Criteria of assessment	The criteria of assessment are stated in the Examination Policies and Procedures

FACTS ABOUT THE MODULE

Danish title	Avanceret effektelektronik og anvendelser
Module code	N-EE-K2-12B
Module type	Course
Duration	1 semester
Semester	Spring
ECTS	5
Language of instruction	English
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg
Responsible for the module	Tamas Kerekes, Matthias Mandø

ORGANISATION

Study Board	Study Board of Energy
Department	Department of Energy
Faculty	The Faculty of Engineering and Science

NON-LINEAR CONTROL AND RELIABILITY

2024/2025

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

The module is based on knowledge achieved in Fundamental Control Theory.

LEARNING OBJECTIVES

KNOWLEDGE

- Be able to analyse systems using linearization and phase plane analysis
- Have comprehension of fundamental concepts and terms of non-linear systems and non-linear control theory
- Have comprehension of Lyapunov's methods for stability analysis and non-linear control theory
- Have comprehension of how to apply reliability and robust design approach during product development
- Understand statistics that support robustness and reliability
- Have knowledge about cost of poor quality in a product life□ time
- Be able to establish mission profile for different applications and use it into the useful reliability context
- Understand difference between preventive scheduled maintenance or maintenance degradation
- Have comprehension of stressor components like temperature, humidity, vibration and their impact
- Be able to model and determine lifetime of components
- Understand physics of failure approach and failure mechanism – both in normal operations and beyond

SKILLS

- Be able to use basic mathematical tools for analysing the response and stability of non-linear systems
- Be able to apply selected methods for non-linear control design
- Be able to implement designed non-linear controller using digital tools
- Be able to set up simple methods for reliability targets and field analysis
- Be able to set up lifetime requirement at function level or component level
- Have knowledge of how to use test methods for reliability and robustness assessment
- Be able to judge the usefulness of the applied control and reliability methods
- Be able to relate the control and reliability methods to applications in industry

COMPETENCES

- Independently be able to define and analyse scientific problems within the area of non-linear control
- Independently be able to be a part of professional and interdisciplinary development work within the area of non-linear control
- Be able to build a system reliability model
- Set up design limits in respect to reliability
- Be able to specify test procedures for new product development

TYPE OF INSTRUCTION

The course is taught by a mixture of lectures, workshops, exercises, mini projects or self-studies, including e-learning.

EXTENT AND EXPECTED WORKLOAD

Since it is a 5 ECTS course module, the work load is expected to be 150 hours for the student

EXAM

EXAMS

Name of exam	Non-linear Control and Reliability

Type of exam	Oral exam
ECTS	5
Permitted aids	With certain aids: For more information about permitted aids, please visit the course description in Moodle.
Assessment	7-point grading scale
Type of grading	Internal examination
Criteria of assessment	The criteria of assessment are stated in the Examination Policies and Procedures

FACTS ABOUT THE MODULE

Danish title	Ulineær styring og pålidelighed
Module code	E-APEL-K2-2B
Module type	Course
Duration	1 semester
Semester	Spring
ECTS	5
Language of instruction	English
Empty-place Scheme	Yes
Location of the lecture	Campus Esbjerg
Responsible for the module	Matthias Mandø

ORGANISATION

Education owner	Master of Science (MSc) in Engineering (Advanced Power Electronics)
Study Board	Study Board of Build, Energy, Electronics and Mechanics in Esbjerg
Department	Department of Energy
Faculty	The Faculty of Engineering and Science

PROJECT-ORIENTED STUDY IN AN EXTERNAL ORGANISATION

2024/2025

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

The module is based on knowledge achieved when studying the previous semesters on the Master of Science in Energy Engineering, the Master of Science in Sustainable Energy Engineering, or similar.

LEARNING OBJECTIVES

KNOWLEDGE

- Have knowledge about analytical, numerical and/or experimental methods for analysis of advanced tasks within the field of the external organisation
- Understand the connection between theory and practice
- Have knowledge about the organisational structure and the work of an organisation seen from an engineering/managerial perspective

SKILLS

- Be able to apply analytical, numerical and/or experimental methods for analysis and solving of advanced tasks within the field of the external organisation using digital platforms
- Be able to compare and evaluate assumptions, limitations and uncertainties related to the methods applied in connection to finding solutions of advanced challenges within the field of the external organisation

COMPETENCES

- Be able to handle development-oriented situations in connection to either studying or working
- Be able to use the correct terminology in oral, written or graphical communication and documentation of challenges and solutions within the field of the external organisation
- Be able to analyse the academic, professional and social benefits of the traineeship
- Be able to communicate these results in a project report
- Be able to evaluate the learning result of the traineeship

TYPE OF INSTRUCTION

The student works in a company providing experience in solving advanced and relevant engineering tasks on a level corresponding to the study programme's 3rd semester and with a progression in the degree of difficulty of the tasks during the period. The type of work must allow for an academic report to be made. The student writes a project report within the theme of the third semester of the specialisation, cf. "Guidelines for Project Work in an External Organisation (Voluntary Traineeship)".

EXTENT AND EXPECTED WORKLOAD

Since it is a 30 ECTS project module, the work load is expected to be 900 hours for the student.

EXAM

EXAMS

Name of exam	Project-Oriented Study in an External Organisation
Type of exam	Oral exam based on a project An oral and individual examination based on a project report.

ECTS	30
Permitted aids	With certain aids: For more information about permitted aids, please visit the course description in Moodle.
Assessment	7-point grading scale
Type of grading	Internal examination
Criteria of assessment	The criteria of assessment are stated in the Examination Policies and Procedures

FACTS ABOUT THE MODULE

Danish title	Projektorienteret forløb i en virksomhed
Module code	N-EE-K3-7A
Module type	Project
Duration	1 semester
Semester	Autumn
ECTS	30
Language of instruction	English
Location of the lecture	Other location
Responsible for the module	Tamas Kerekes, Matthias Mandø

ORGANISATION

Study Board	Study Board of Energy
Department	Department of Energy
Faculty	The Faculty of Engineering and Science

ADVANCED CONTROL IN INDUSTRIAL ELECTRONICS 2024/2025

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

The module is based on knowledge achieved from the courses in Non-linear Control and Reliability and System Identification and Diagnosis.

LEARNING OBJECTIVES

KNOWLEDGE

- Have knowledge about the electronics in industrial processes
- Be able to identify, model and control uncertain and varying industrial processes
- Have knowledge about the methodology used for applying industrial electronics
- Have insight in how to apply reliable electronics to keeping reliable operational performance
- Be able to implement industrial electronics for advanced closed-loop control solutions, for instance model predictive control (MPC) and artificial intelligence

SKILLS

- Be able to design a complete embedded system operating with industrial electronics
- Be able to design hardware and software which successfully can stabilize complicated processes during uncertain and varying conditions applying artificial intelligence
- Be able to design efficient controllers for disturbance rejections
- Be able to implement hardware applications related to industrial electronics
- Be able to synthesize, document and bring entire systems (hardware and software) to working condition, when the operating conditions are uncertain

COMPETENCES

- Be able to design industrial electronics based on the design specifications
- Independently identify and analyse complicated industrial processes
- Independently understand the concepts of predictive and adaptive control strategies and artificial intelligence application for industrial processes
- Be able to control the working and development process within the project theme, and be able to develop feasible solutions within optimisation, control, and/or diagnostic within advanced control of industrial electronics
- Be able to show entrepreneurship to define and analyse scientific problems in the area of optimisation, control, and/or diagnostic within advanced control of industrial electronics, and based on that make and state the reasons for decisions made
- Be able to set up innovative ideas within the area of optimisation, control, and/or diagnostic within advanced control of industrial electronics
- Independently be able to continue own development in competence and specialisation
- Be able to follow more sophisticated literature, or state-of-the-art, within the topic of optimisation, control or diagnostic within advanced control of industrial electronics
- Be able to implement and test the developed controllers with the purpose of verifying the hypothesis, as well as draw conclusions based on the achieved result

TYPE OF INSTRUCTION

Problem based project organised work in groups.

The project can be made in cooperation with external partners and the project can be a disciplinary project, a cross disciplinary project or a part of a multi-disciplinary project, where several groups from the department do different parts of a larger project. Finally, the project can also be a part of a so-called MEGA project also in cooperation with industry, where several project groups from more departments are participating, each doing their part of the large project to find a total solution.

The project work must be documented by a scientific paper (max. 8 pages) accompanied by a project summary report. The project summary report should elaborate the project details and conclusions. The maximum length of the summary report (report without appendices) is 50 pages. For more information see semester description in Moodle.

The scientific paper will be presented at a conference arranged within the Department of Energy, prior to the project examination.

The project must include an application that includes a power electronic converter, a power source and embedded system. The operating principles for the system must be described and a control problem is formulated including key specifications. A dynamic simulation model is made taking the relevant dynamics into account. Different advanced control methods like predictive, adaptive, and robust control strategies or use of artificial intelligence are designed, analysed and evaluated by means of the simulation model. At least one method is selected for practical implementation in a real system incorporating hardware and software and a real□ time digital advanced control system based on a digital signal processor or a microcontroller. Finally, the whole system is tested and the developed control strategies are evaluated with the purpose of verifying the hypothesis, as well as drawing conclusions based on the achieved result.

If there are special technical or scientific documentation requirements, the student documents the project work in a project report, which can be prepared individually or in a group within the project theme. However, the student's special preferences for the semester must be approved by the Study Board in advance.

EXTENT AND EXPECTED WORKLOAD

Since it is a 20 ECTS project module, the work load is expected to be 600 hours for the student.

EXAM

PREREQUISITE FOR ENROLLMENT FOR THE EXAM

- It is a pre-condition that the student has submitted a scientific paper and presented the scientific paper at an internal conference prior to the project examination.
- In case of a re-exam, the student will have to present the scientific paper in front of a committee made up of the supervisor and at least one internal adjudicator.

EXAMS

Name of exam	Advanced Control in Industrial Electronics
Type of exam	Oral exam based on a project The project group should orally present the project work and scientific paper as specified in the Examination Policies and Procedures. The project group members will undergo an oral examination with internal adjudicator, based on the scientific paper and the project summary report.
ECTS	20
Permitted aids	With certain aids: For more information about permitted aids, please visit the course description in Moodle.
Assessment	7-point grading scale
Type of grading	Internal examination
Criteria of assessment	The criteria of assessment are stated in the Examination Policies and Procedures

FACTS ABOUT THE MODULE

Danish title	Avanceret styring af industriel elektronik
Module code	E-APEL-K3-1C
Module type	Project

Duration	1 semester
Semester	Autumn
ECTS	20
Language of instruction	English
Empty-place Scheme	Yes
Location of the lecture	Campus Esbjerg
Responsible for the module	Matthias Mandø

ORGANISATION

Education owner	Master of Science (MSc) in Engineering (Advanced Power Electronics)
Study Board	Study Board of Build, Energy, Electronics and Mechanics in Esbjerg
Department	Department of Energy
Faculty	The Faculty of Engineering and Science

MASTER'S THESIS

2024/2025

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

The module is based on knowledge achieved when studying previous semesters on the Master of Science in Advanced Power Electronics, or similar

LEARNING OBJECTIVES

KNOWLEDGE

- Have knowledge and comprehension within the area of advanced power electronics at the highest international level
- Be able to critically judge knowledge and identify new scientific problems within the area of advanced power electronics
- Have comprehension of the implications within the research work (research ethics)

SKILLS

- Be able to judge the usefulness of different scientific methods and digital tools for analysis and problem solving within the field of advanced power electronics
- Be able to use advanced laboratory set-ups or by using real measured data series combined with data analysis methods and analysis and modelling methods within the field of advanced power electronics
- Be able to communicate about scientific problems both to specialists and the public
- Have obtained skills related to the industrial area within advanced power electronics

COMPETENCES

- Be able to control complex/unexpected working and development situations within advanced power electronics, and be able to develop new solutions using digital platforms
- Be able to independently define and analyse scientific problems, and based on that make and state the reasons for decisions made
- Be able to independently continue own development in competence and specialisation
- Be able to independently be the head of professional and interdisciplinary development work and be able to undertake the professional responsibility including reporting

TYPE OF INSTRUCTION

Problem based project organised work in groups.

The final project may study new subjects or be an extension of the project work from previous semesters. The subject matter will remain in the area of advanced power electronics. The project may be of an experimental nature and will often be in collaboration with an industrial company or other research institution performing research in the area of advanced power electronics.

EXTENT AND EXPECTED WORKLOAD

Since it is a 50 ECTS project module, the work load is expected to be 1500 hours for the student.

The long master thesis has to include experimental work and has to be approved by the study board. The amount of experimental work must reflect the allotted ECTS.

EXAM

EXAMS

Name of exam	Master’s Thesis
Type of exam	Master's thesis/final project
ECTS	50
Permitted aids	With certain aids: For more information about permitted aids, please visit the course description in Moodle.
Assessment	7-point grading scale
Type of grading	External examination
Criteria of assessment	The criteria of assessment are stated in the Examination Policies and Procedures

FACTS ABOUT THE MODULE

Danish title	Kandidatspeciale
Module code	E-APEL-K4-1L
Module type	Project
Duration	2 semesters
Semester	Autumn
ECTS	50
Language of instruction	English
Empty-place Scheme	Yes
Location of the lecture	Campus Esbjerg
Responsible for the module	Matthias Mandø

ORGANISATION

Education owner	Master of Science (MSc) in Engineering (Advanced Power Electronics)
Study Board	Study Board of Build, Energy, Electronics and Mechanics in Esbjerg
Department	Department of Energy
Faculty	The Faculty of Engineering and Science

MASTER'S THESIS

2024/2025

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

The module is based on knowledge achieved when studying the 3rd semester on the Master of Science in Advanced Power Electronics, or similar

LEARNING OBJECTIVES

KNOWLEDGE

- Have knowledge and comprehension within the area of advanced power electronics at the highest international level
- Be able to critically judge knowledge and identify new scientific problems within the area of advanced power electronics
- Have knowledge about the implications within the research work (research ethics)

SKILLS

- Be able to judge the usefulness of different scientific methods and digital tools for analysis and problem solving within the field of advanced power electronics
- Be able to use advanced laboratory set-ups or by using real measured data series combined with data analysis methods and analysis and modelling methods within the field of advanced power electronics
- Be able to communicate about scientific problems both to specialists and the public
- Have obtained skills related to the industrial area within advanced power electronics

COMPETENCES

- Be able to control complex/unexpected working and development situations within advanced power electronics, and be able to develop new solutions
- Be able to independently define and analyse scientific problems, and based on that make and state the reasons for decisions made
- Be able to independently continue own development in competence and specialisation
- Be able to independently be the head of professional and interdisciplinary development work and be able to undertake the professional responsibility including reporting

TYPE OF INSTRUCTION

Problem based project organised work in groups.

The final project may study new subjects or be an extension of the project work from previous semesters. The project can be a disciplinary project, a cross disciplinary project or a part of a multi-disciplinary project, where several groups from the department do different parts of a larger project. Finally, the project can also be a part of a so-called MEGA project where several project groups from more departments are participating, each doing their part of the large project to find a total solution.

The subject matter will remain in the area of advanced power electronics. The project may be of theoretical or experimental nature and will often be in collaboration with an industrial company or other research institution performing research in the area of advanced power electronics.

EXTENT AND EXPECTED WORKLOAD

Since it is a 30 ECTS project module, the work load is expected to be 900 hours for the student

EXAM

EXAMS

Name of exam	Master’s Thesis
Type of exam	Master's thesis/final project
ECTS	30
Permitted aids	With certain aids: For more information about permitted aids, please visit the course description in Moodle.
Assessment	7-point grading scale
Type of grading	External examination
Criteria of assessment	The criteria of assessment are stated in the Examination Policies and Procedures

FACTS ABOUT THE MODULE

Danish title	Kandidatspeciale
Module code	E-APEL-K4-1C
Module type	Project
Duration	1 semester
Semester	Spring
ECTS	30
Language of instruction	English
Empty-place Scheme	Yes
Location of the lecture	Campus Esbjerg
Responsible for the module	Matthias Mandø

ORGANISATION

Education owner	Master of Science (MSc) in Engineering (Advanced Power Electronics)
Study Board	Study Board of Build, Energy, Electronics and Mechanics in Esbjerg
Department	Department of Energy
Faculty	The Faculty of Engineering and Science

ADVANCED MODELLING AND CONTROL OF VOLTAGE SOURCE CONVERTERS

2024/2025

RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

The module is based on knowledge achieved when studying the 2nd semester on the Master of Science in Energy Engineering with an electrical specialisation or Master of Science in Sustainable Energy Engineering with specialisation in Offshore Energy Systems or the Master of Science in Advanced Power Electronics.

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Have knowledge about average and small-signal models for voltage Source Converter (VSC) circuits including pulse-width modulators and different output filters
- Understand impedance-based approach to get an insightful yet easy-to-implement way for controller design and stability assessment of VSCs
- Understand impedance-based stability analysis of grid synchronisation and outer DC link voltage control loops
- Understand equivalence and differences between models represented by single-input single-output complex transfer functions and multi-input multi-output transfer matrices
- Have knowledge about passivity-based stability analysis and control for robustly stable VSCs with different grid conditions
- Have knowledge about virtual-impedance-based control for active stabilisation and harmonic compensation of VSCs

SKILLS

- Be able to develop small-signal models for the closed-loop-controlled VSC with closed correlations with time-domain simulations
- Be able to design current controller, phase-locked loop, and DC link voltage controllers under given dynamic specifications
- Be able to identify the causes of the different instability phenomena of grid-connected VSCs
- Be able to design and implement different active damping controllers for stabilizing VSCs

COMPETENCES

- Be able to deal with the instability problems in the emerging VSCs-based power systems, which are nowadays commonly found in renewable power plants, electric transportation systems, and flexible ac/dc transmission/distribution systems

TYPE OF INSTRUCTION

The course is taught by a mixture of lectures, workshops, exercises in simulations (PLECS) and experiments (dSPACE 1007). Guest lectures relevant to the course will also be involved together with possible e-learning activities.

EXTENT AND EXPECTED WORKLOAD

Since it is a 5 ECTS course module, the work load is expected to be 150 hours for the student.

EXAM

EXAMS

Name of exam	Advanced Modelling and Control of Voltage Source Converters
Type of exam	Oral exam based on a project Students should do a mini project and submit the report in groups, and then an oral examination will be held.
ECTS	5
Permitted aids	With certain aids: For more information about permitted aids, please visit the course description in Moodle.
Assessment	7-point grading scale
Type of grading	Internal examination
Criteria of assessment	The criteria of assessment are stated in the Examination Policies and Procedures

FACTS ABOUT THE MODULE

Danish title	Avancerede modellering og regulering af effektelektroniske konvertere
Module code	N-EE-K3-9A
Module type	Course
Duration	1 semester
Semester	Autumn
ECTS	5
Language of instruction	English
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg, Campus Esbjerg
Responsible for the module	Tamas Kerekes, Matthias Mandø

ORGANISATION

Study Board	Study Board of Energy
Department	Department of Energy
Faculty	The Faculty of Engineering and Science

ADAPTIVE AND PREDICTIVE CONTROL

2024/2025

RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

The module is based on knowledge achieved in Control theory and Digital and modern control.

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Have knowledge and understanding within adaptive control techniques, such as gain scheduling, self-tuning regulators, and model reference adaptive control
- Have knowledge about principles and standard schemes of model predictive control techniques
- Have knowledge about formulating the model predictive control for a given system considering cost functions and constraints

SKILLS

- Be able to use model-based adaptive control and model predictive control, which can act as efficient control design methods for control systems
- Be able to analyse the dynamic behaviour of an adaptive control and model predictive control system
- Be able to investigate stability of an adaptive or model predictive control system
- Be able to implement model predictive control using relevant optimisation software
- Be able to design and simulate adaptive and predictive controllers and make judgment of the benefits and drawbacks of the used techniques

COMPETENCES

- Be equipped with fundamental knowledge and basic skills in the areas of adaptive and predictive control
- Be able to define and analyse scientific problems within the area of adaptive and predictive control
- Be able to select proper adaptive and predictive control methods and apply the selected methods into real-life applications
- Be able to be a part of professional and interdisciplinary development work within the area of adaptive and predictive control

TYPE OF INSTRUCTION

The course is taught by a mixture of lectures, workshops, exercises, mini-projects or self-studies, including e-learning.

EXTENT AND EXPECTED WORKLOAD

Since it is a 5 ECTS course module, the work load is expected to be 150 hours for the student

EXAM

EXAMS

Name of exam	Adaptive and Predictive Control
Type of exam	Oral exam
ECTS	5
Permitted aids	With certain aids:

	For more information about permitted aids, please visit the course description in Moodle.
Assessment	7-point grading scale
Type of grading	Internal examination
Criteria of assessment	The criteria of assessment are stated in the Examination Policies and Procedures

FACTS ABOUT THE MODULE

Danish title	Adaptive og prediktiv styring
Module code	N-APEL-K3-4A
Module type	Course
Duration	1 semester
Semester	Autumn
ECTS	5
Language of instruction	English
Empty-place Scheme	Yes
Location of the lecture	Campus Esbjerg
Responsible for the module	Matthias Mandø

ORGANISATION

Education owner	Master of Science (MSc) in Engineering (Advanced Power Electronics)
Study Board	Study Board of Build, Energy, Electronics and Mechanics in Esbjerg
Department	Department of Energy
Faculty	The Faculty of Engineering and Science

ARTIFICIAL INTELLIGENCE

2024/2025

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

The module is based on Linear algebra, calculus and probability theory, and knowledge about programming in one or more of the modern computer languages.

LEARNING OBJECTIVES

KNOWLEDGE

- Have knowledge about the fundamental concepts and theories in artificial intelligence (AI)
- Have knowledge about the algorithmic search and optimisation techniques used in AI, such as depth-first, bread-first search and gradient decent or particle swarm optimisation
- Have knowledge about how to model uncertainty in AI using probabilistic methods and/or fuzzy logic
- Have knowledge about machine learning techniques, such as artificial neural networks, Bayesian networks, clustering, classification and its applications

SKILLS

- Be able to design AI based models and algorithms for specific applications using digital platforms
- Be able to develop computer programs to implement one or more of the techniques used in artificial intelligence
- Be able to design AI based solutions and implement them in an embedded processor or computer

COMPETENCES

- Independently be able to apply modelling techniques in AI using connectionist and/or probabilistic methods
- Independently develop artificial intelligence based system solutions in specific problems using digital platforms
- Have a fundamental understanding of the modern techniques used in AI, such as deep learning and its applications, for example in big data problems

TYPE OF INSTRUCTION

Lectures with exercises supplemented with e-learning activities.

EXTENT AND EXPECTED WORKLOAD

Since it is a 5 ECTS course module, the work load is expected to be 150 hours for the student

EXAM

EXAMS

Name of exam	Artificial Intelligence
Type of exam	Written or oral exam
ECTS	5
Permitted aids	With certain aids: For more information about permitted aids, please visit the course description in Moodle.
Assessment	7-point grading scale
Type of grading	Internal examination

Criteria of assessment	The criteria of assessment are stated in the Examination Policies and Procedures

FACTS ABOUT THE MODULE

Danish title	Kunstig intelligens
Module code	N-APEL-K3-3B
Module type	Course
Duration	1 semester
Semester	Autumn
ECTS	5
Language of instruction	English
Empty-place Scheme	Yes
Location of the lecture	Campus Esbjerg
Responsible for the module	Matthias Mandø

ORGANISATION

Education owner	Master of Science (MSc) in Engineering (Advanced Power Electronics)
Study Board	Study Board of Build, Energy, Electronics and Mechanics in Esbjerg
Department	Department of Energy
Faculty	The Faculty of Engineering and Science

APPLIED OPTIMISATION FOR ENERGY SYSTEMS ENGINEERING: THEORY AND PRACTICE

2024/2025

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

The module is based on knowledge achieved in Probability Theory, Stochastic Processes and Applied Statistics and Optimisation Theory and Reliability.

LEARNING OBJECTIVES

KNOWLEDGE

- Knowledge of integrated electrical/thermal energy systems engineering problems, which are suitable for optimisation
- Knowledge of building different programming models such as non-linear models and mixed-integer programming, and solving them using appropriate methods
- Knowledge of optimisation tools suited optimization of integrated electrical/thermal energy systems.
- Knowledge about the optimal design and planning of energy systems (system configuration, placement and sizing of energy-related devices)
- Knowledge about optimal operation and scheduling of different energy systems such as multi-energy systems and micro grids, and integrated systems such as power-gas and power-heat networks
- Knowledge about models for optimal dispatch of energy sources considering technical constraints and regulatory frameworks
- Knowledge about incorporation of optimisation techniques in energy systems economics

SKILLS

- Ability to analyse and solve advanced optimisation problems such as mixed-integer non-linear, non-deterministic and non-control flow programs
- Ability to judge the usefulness of different scientific methods for analysis (e.g. cost-benefit) and modelling of energy systems using digital platforms
- Ability to verify the analytical and numerical approaches by means of experimental data.
- Ability to integrate optimisation models into real-life problems and analyse effectiveness of solutions in practice
- Ability to select an appropriate optimisation procedure and tool for the energy systems and evaluate the optimisation results

COMPETENCES

- Communicate technical issues with specialists in cross-disciplinary teams and the public
- Conscious attitude towards the use of appropriate optimisation tools and techniques within energy systems engineering (specifically electric/thermal engineering)
- Control the working and development process within the project theme, and develop new and efficient solutions within the energy sector
- Define and analyse scientific problems in the area of modelling and optimisation of energy systems

TYPE OF INSTRUCTION

The Master's programme is based on a combination of academic, problem oriented and interdisciplinary approaches and organised based on the following types of instruction that combine skills and reflection:

- Lectures
- Class teaching
- Project work
- Workshops
- Exercises (individually and in groups)
- Digital learning in different ways including flipped class room, blended learning, game or quiz

- Supervisor feedback
- Professional reflection
- Portfolio work
- Laboratory work

EXTENT AND EXPECTED WORKLOAD

Since it is a 5 ECTS course module, the work load is expected to be 150 hours for the student

EXAM

EXAMS

Name of exam	Applied Optimization for Energy Systems Engineering: Theory and Practice
Type of exam	Oral exam
ECTS	5
Permitted aids	With certain aids: For more information about permitted aids, please visit the course description in Moodle.
Assessment	7-point grading scale
Type of grading	Internal examination
Criteria of assessment	The criteria of assessment are stated in the Examination Policies and Procedures

FACTS ABOUT THE MODULE

Danish title	Anvendt optimering af energisystemer: Teori og praksis
Module code	N-EE-K3-23B
Module type	Course
Duration	1 semester
Semester	Autumn
ECTS	5
Language of instruction	English
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg, Campus Esbjerg
Responsible for the module	Tamas Kerekes, Matthias Mandø

ORGANISATION

Study Board	Study Board of Build, Energy, Electronics and Mechanics in Esbjerg
Department	Department of Energy
Faculty	The Faculty of Engineering and Science

CONTROL OF GRID CONNECTED PHOTOVOLTAIC AND WIND TURBINE SYSTEMS

2024/2025

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

The module is based on knowledge achieved when studying the 2nd semester on the Master of Science in Energy Engineering with an electrical specialisation or Master of Science in Sustainable Energy Engineering with specialisation in Offshore Energy Systems or the Master of Science in Advanced Power Electronics.

LEARNING OBJECTIVES

KNOWLEDGE

- Understand the operation principle of most common PV and WT systems
- Have knowledge about the most important single- and three-phase inverter topologies, used in renewable energy systems
- Have knowledge about the various pulse width modulation (PWM) techniques used with different inverter topologies
- Understand maximum power point trackers
- Have knowledge about different phase-lock loop (PLL) and control methods, current, voltage and power loops used in control schemes of grid connected inverters
- Have knowledge about grid requirements, standards describing anti-islanding methods, THD limits, etc. that grid connected inverters must comply with

SKILLS

- Be able to implement different PWM strategies for single- and three-phase converters using digital platforms
- Be able to verify different PLL methods based on laboratory experiments
- Be able to design/tune a control scheme for a grid connected converter

COMPETENCES

- Be able to create mathematical models for PV cells, panels and arrays
- Be able to develop simulation models for different PV and WT converter
- Be able to implement a grid connected converter control using digital platforms
- Understand the purpose and methods for grid support by renewable systems

TYPE OF INSTRUCTION

The course will be planned and organised in close interaction with on-going research and development activities at the Department of Energy and its collaborators. Project topics are accounted for when determining the course content. Guest lecturers and e-learning activities will also be involved if this is relevant to the course aims. All lectures include exercises focusing on the presented material. Some of the exercises will be done using MATLAB and Simulink. Several exercises will be performed in the PV-lab using experimental set-ups, like current control for a grid connected converter using dSPACE 1103. This way the participants will get a hands-on experience will real-life systems.

EXTENT AND EXPECTED WORKLOAD

Since it is a 5 ECTS course module, the work load is expected to be 150 hours for the student.

EXAM

EXAMS

Name of exam	Control of Grid Connected Photovoltaic and Wind Turbine Systems
Type of exam	Oral exam based on a project Each student should submit all the laboratory exercises in the form of a report. The oral examination will be based on the submitted report and the presented material.
ECTS	5
Permitted aids	With certain aids: For more information about permitted aids, please visit the course description in Moodle.
Assessment	7-point grading scale
Type of grading	Internal examination
Criteria of assessment	The criteria of assessment are stated in the Examination Policies and Procedures

FACTS ABOUT THE MODULE

Danish title	Regulering af nettilsluttede solcelle-og vindmøllesystemer
Module code	N-EE-K3-14B
Module type	Course
Duration	1 semester
Semester	Autumn
ECTS	5
Language of instruction	English
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg, Campus Esbjerg
Responsible for the module	Tamas Kerekes, Matthias Mandø

ORGANISATION

Study Board	Study Board of Build, Energy, Electronics and Mechanics in Esbjerg
Department	Department of Energy
Faculty	The Faculty of Engineering and Science

FAULT TOLERANT CONTROL

2024/2025

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

The module is based on knowledge achieved when studying classic and modern control theories.

LEARNING OBJECTIVES

KNOWLEDGE

- Have comprehension of the fundamental concepts, terms and methods used within fault tolerant control
- Have comprehension of failure mode and effect analysis (FMEA)
- Have comprehension of modelling faults in dynamic systems and closed loop control systems
- Have comprehension of analytical redundancy

- Have knowledge about statistical fault detection including cumulative sum and generalised likelihood tests
- Have comprehension of residual generation for detection and isolation and decision ruling
- Have comprehension of fault detection using both observers and parity methods

SKILLS

- Be able to use analyse fault development and mitigation approaches
- Be able to list considered faults, how they propagate through the system and assess their severity and occurrence likelihood
- Be able to design fault detection observers using digital platforms
- Be able to design fault detection with parity equations
- Be able to design a FDI observer for unknown inputs
- Be able to develop fault tolerant strategies for ensuring the continuation of the system in the presence of faults
- Be able to design both passive and active fault tolerant controller for continuous systems

COMPETENCES

- Be able to account for the considerations involved in the process of formulating and solving fault tolerant control problems, choosing suited approaches and implementing it in practice using digital platforms
- Be able to develop fault detection and isolation (FDI) algorithms

TYPE OF INSTRUCTION

The form(s) of teaching will be determined and described in connection with the planning of the semester. The description will account for the form(s) of teaching and may be accompanied by an elaboration of the roles of the participants. The programme is based on a combination of academic, problem oriented and interdisciplinary approaches and organised based on the following types of instruction that combine skills and reflection:

- lectures
- project work
- workshops
- exercises (individually and in groups)
- e-learning in different ways such as flipped class-room, blended learning, game or quiz, etc.
- teacher feedback
- reflection
- portfolio work
- study circle
- self-study

EXTENT AND EXPECTED WORKLOAD

Since it is a 5 ECTS course module, the work load is expected to be 150 hours for the student.

EXAM

EXAMS

Name of exam	Fault Tolerant Control
Type of exam	Written exam
ECTS	5
Permitted aids	With certain aids: For more information about permitted aids, please visit the course description in Moodle.
Assessment	7-point grading scale
Type of grading	Internal examination
Criteria of assessment	The criteria of assessment are stated in the Examination Policies and Procedures

FACTS ABOUT THE MODULE

Danish title	Fejltolerant regulering
Module code	N-EE-K3-17B
Module type	Course
Duration	1 semester
Semester	Autumn
ECTS	5
Language of instruction	English
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg, Campus Esbjerg
Responsible for the module	Tamas Kerekes, Matthias Mandø

ORGANISATION

Study Board	Study Board of Build, Energy, Electronics and Mechanics in Esbjerg
Department	Department of Energy
Faculty	The Faculty of Engineering and Science

HYBRID POWER PLANTS

2024/2025

RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

The module is based on knowledge achieved when studying the 2nd semester on the Master of Science in Energy Engineering with an electrical specialisation or Master of Science in Sustainable Energy Engineering with specialisation in Offshore Energy Systems or the Master of Science in Advanced Power Electronics.

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Understand the architecture, operational strategies and market integration of hybrid power plants comprising of renewable energy sources such as wind and solar PV, energy storage systems and flexible electrical loads e.g. electrolyzers
- Have knowledge on monitoring, control and interoperability in hybrid power plants
- Have knowledge on information and communication technologies (ICT) including protocols utilized in hybrid power plants
- Have knowledge on optimisation techniques required for sizing and operation of hybrid power plants
- Have knowledge on participation of hybrid power plants in day ahead and ancillary service markets
- Have knowledge on Real-Time Control-in-the-Loop simulation techniques for hybrid power plants

SKILLS

- Be able to design and tune a hybrid power plant controller
- Be able to apply a model-based design approach for verification and validation of hybrid power plant controllers
- Be able to ensure grid compliance of hybrid power plants

COMPETENCES

- Be able to develop mathematical models for various assets in a hybrid power plant e.g. wind turbines, solar PV, batteries, electrolyzers, grid meters, communication, etc.
- Be able to develop simulation models for hybrid power plants to ensure grid compliance
- Be able to implement hybrid power plant control on commercial controllers (PLCs)

TYPE OF INSTRUCTION

The course will be planned and organised in close interaction with on-going research and development activities at the Department of Energy and its collaborators.

Project topics are accounted for when determining the course content.

Guest lecturers and e-learning activities will also be involved if this is relevant to the course aims. All lectures include exercises focusing on the presented material. All exercises will be done using MATLAB and Simulink. Several exercises will be performed in the Smart Energy Systems Lab using Opal-RT and industrial controllers. In this way the participants will get a hands-on experience with real-life systems.

EXTENT AND EXPECTED WORKLOAD

Since it is a 5 ECTS course module, the work load is expected to be 150 hours for the student.

EXAM

EXAMS

Name of exam	Hybrid Power Plants
Type of exam	Oral exam based on a project Oral examination based on the submitted report with solution of assignments. Each student must submit all the laboratory exercises in the form of a report. The oral examination will be based on the submitted report and the presented material.
ECTS	5
Permitted aids	With certain aids: For more information about permitted aids, please visit the course description in Moodle.
Assessment	7-point grading scale
Type of grading	Internal examination
Criteria of assessment	The criteria of assessment are stated in the Examination Policies and Procedures

FACTS ABOUT THE MODULE

Danish title	Hybride vedvarende energianlæg
Module code	N-EE-K3-28
Module type	Course
Duration	1 semester
Semester	Autumn
ECTS	5
Language of instruction	English
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg
Responsible for the module	Tamas Kerekes

ORGANISATION

Study Board	Study Board of Energy
Department	Department of Energy
Faculty	The Faculty of Engineering and Science

MODERN ELECTRICAL DRIVES

2024/2025

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

The module is based on knowledge achieved when studying the 2nd semester on the Master of Science in Energy Engineering with an electrical specialisation or Master of Science in Sustainable Energy Engineering with specialisation in Offshore Energy Systems or the Master in Advanced Power Electronics.

LEARNING OBJECTIVES

KNOWLEDGE

- Have a solid knowledge about the electromagnetic field behaviour for various types of electrical machines. This gives a firm base for understanding of the advantages and disadvantages of different types of electrical machines. It consequently leads to a good understanding of new types of machines invented in recent years, e.g. the modern drive unit in electric vehicles or wind turbines, and magnetic gears.
- Have a detailed knowledge of the small DC link drive system and the corresponding active damping control methods. This has become a hot topic in recent years.
- Gain good experience about design of various controllers to meet different requirements, e.g. very low speed stable operation, low-cost controller design, drive stability issues, etc.

SKILLS

- Be able to understand and evaluate new types of high performance electrical machines that may occur in the future
- Be able to identify the pros and cons of existing sensorless control methods and design the most proper controller for selected applications using digital platforms
- Be aware of important practical implementation issues when designing the controller
- Be able to test, measure and characterize the performance of different electrical drive systems

COMPETENCES

- Independently be able to contribute to a professional team dealing with design of modern electrical drives, including new high performance electrical machines and advanced control technologies using digital platforms

TYPE OF INSTRUCTION

The course is taught by a mixture of lectures, workshops, exercises, mini-projects and self-studies including e-learning activities. Instead of using complicated mathematical equations and electromagnetic theory, particularly-made Finite Element Models visualizing the electromagnetic field behaviour inside a machine will be used to give an easy but deep access to many difficult topics involved in the electrical machine theory. Various advanced sensorless control technologies developed in recent years will be discussed for permanent magnet machine and synchronous reluctance machine (which has received great interests in recent years). Achievements obtained from recent PhD projects carried out at the department will be presented.

EXTENT AND EXPECTED WORKLOAD

Since it is a 5 ECTS course module, the work load is expected to be 150 hours for the student.

EXAM

EXAMS

Name of exam	Modern Electrical Drives

Type of exam	Oral exam based on a project Oral examination based on a delivered mini-project/test report (individual or made in groups).
ECTS	5
Permitted aids	With certain aids: For more information about permitted aids, please visit the course description in Moodle.
Assessment	7-point grading scale
Type of grading	Internal examination
Criteria of assessment	The criteria of assessment are stated in the Examination Policies and Procedures

FACTS ABOUT THE MODULE

Danish title	Moderne elektriske drivsystemer
Module code	N-EE-K3-19B
Module type	Course
Duration	1 semester
Semester	Autumn
ECTS	5
Language of instruction	English
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg, Campus Esbjerg
Responsible for the module	Tamas Kerekes, Matthias Mandø

ORGANISATION

Study Board	Study Board of Build, Energy, Electronics and Mechanics in Esbjerg
Department	Department of Energy
Faculty	The Faculty of Engineering and Science

MODERN POWER ELECTRONIC DEVICES AND THEIR MODELS

2024/2025

RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

The module is based on knowledge achieved when studying the 2nd semester on the Master of Science in Energy Engineering with an electrical specialisation or Master of Science in Sustainable Energy Engineering with specialisation in Offshore Energy Systems or similar.

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Have a basic knowledge about figure of merit of present and future wide-bandgap semiconductor materials (SiC, GaN, GaO, diamond, etc.)
- Have a solid knowledge about operating principles and founding equations of modern power electronic devices: SCRs, MOSFETs, IGBTs, rectifiers, FR diodes, Schottky diodes, HEMTs, etc.
- Have a solid knowledge about operating range basing on real-life application, like LVDO, POL, power supplies, welding machines, solar inverters, wind turbines, HVDC, etc.
- Have a basic knowledge about power electronic device design principles, constraints and trade-offs
- Have a good understanding of simulation tools, both at device level and circuit level (PSpice, LTSpice, etc.)
- Understanding of the interaction between the external circuit, including driving circuit, and the power electronic device
- Have a good knowledge about abnormal conditions and instabilities
- Have a hands-on experience on real problems related to power electronic devices, as driver selection, heatsink thermal design, losses and efficiency estimation and measurement

SKILLS

- Be able to recognise and classify traditional and modern power semiconductor devices
- Be able to test and characterize real power devices, both statically and dynamically
- Be able to simulate with good accuracy electrical behaviour of power electronic devices, including power losses and junction temperature estimation
- Be able to select an appropriate power devices for a given real application, e.g. DC/DC or DC/AC converters
- Experience gained from practical tasks will let you be aware of important implementation issues when designing power electronic circuits, e.g. thermal design, safe operating area, etc.

COMPETENCES

- Be able to contribute to a professional team in design of power electronic circuits with skills on part number selection, driving design and simulation of traditional and modern power electronic components

TYPE OF INSTRUCTION

The course is taught by a mixture of lectures, workshops, exercises, mini-projects and self-studies, including e-learning activities.

EXTENT AND EXPECTED WORKLOAD

Since it is a 5 ECTS course module, the work load is expected to be 150 hours for the student.

EXAM

EXAMS

Name of exam	Modern Power Electronic Devices and their Models
Type of exam	Oral exam based on a project Oral examination based on a delivered mini-project/test report (individual or made in groups).
ECTS	5
Permitted aids	With certain aids: For more information about permitted aids, please visit the course description in Moodle.
Assessment	7-point grading scale
Type of grading	Internal examination
Criteria of assessment	The criteria of assessment are stated in the Examination Policies and Procedures

FACTS ABOUT THE MODULE

Danish title	Moderne effektelektronikkomponenter og deres modeller
Module code	N-EE-K3-20A
Module type	Course
Duration	1 semester
Semester	Autumn
ECTS	5
Language of instruction	English
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg, Campus Esbjerg
Responsible for the module	Tamas Kerekes, Matthias Mandø

ORGANISATION

Study Board	Study Board of Energy
Department	Department of Energy
Faculty	The Faculty of Engineering and Science

TEST AND VALIDATION

2024/2025

RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

The module builds upon knowledge obtained in the modules Applied Statistics and Probability Theory.

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Understand methodology for design of experiments and test series and for reduction of ambiguity of experimental results, and for comparability with model predictions
- Explain elementary and advanced quantification tools, and their application to validation between model and experiment data
- Account for common contemporary methods and relevant specific industry standards
- Understand processing methods for analog and digital data (continuous vs. discrete)

SKILLS

- Scrutinize a non-trivial physical systems for appropriate experimental study
- Isolate principal measurable parameters
- Design an experiment matrix for systematic variation of parameters
- Perform a probabilistic study of the experimental data in order to quantify the influence of individual parameters
- Scrutinize a model (analytical or numerical) for comparison with an appropriate experimental study
- Isolate principal input parameters and their known or assumed statistical variations
- Perform a probabilistic study of the model in order to quantify the level of confidence
- Account for the level of coherence between test results and model predictions
- Identify invalid data (outliers)
- Account for common errors and limitations in the processing of model data or experimentally obtained data

COMPETENCES

- Undertake experiment planning and execution for refinement and validation (or rejection) of model-based predictions of phenomena within their principal line of study

TYPE OF INSTRUCTION

The course is taught by a mixture of lectures, workshops, exercises, mini-projects and self-studies, including e-learning activities.

EXTENT AND EXPECTED WORKLOAD

Since it is a 5 ECTS course module, the work load is expected to be 150 hours for the student.

EXAM

EXAMS

Name of exam	Test and Validation
Type of exam	Oral exam based on a project Oral examination based on a submitted written assignment.
ECTS	5

Permitted aids	With certain aids: For more information about permitted aids, please visit the course description in Moodle.
Assessment	Passed/Not Passed
Type of grading	Internal examination
Criteria of assessment	The criteria of assessment are stated in the Examination Policies and Procedures

FACTS ABOUT THE MODULE

Danish title	Test og validering
Module code	N-EE-K3-21A
Module type	Course
Duration	1 semester
Semester	Autumn
ECTS	5
Language of instruction	English
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg, Campus Esbjerg
Responsible for the module	Matthias Mandø

ORGANISATION

Study Board	Study Board of Energy
Department	Department of Energy
Faculty	The Faculty of Engineering and Science

PERFORMANCE ASSESSMENT AND MODELLING OF BATTERIES

2024/2025

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

The knowledge obtained by the end of the 2nd semester of the MSc in Energy Engineering is enough to complete this course.

After dominating the consumer electronics market, batteries have developed as enablers of the green transition as they are a key technology in the electrification of the transportation sector and decarbonization of the energy generation industry.

The course is aimed at providing students a basic introduction and understanding of the battery performance behaviour. Furthermore, different battery modelling approaches and their specific utilization will be discussed.

LEARNING OBJECTIVES

KNOWLEDGE

- Basic knowledge about different energy storage technologies (i.e. electrical, thermal, electrochemical, etc.)
- Depth knowledge about batteries' operation principles, design, etc.
- Understand the operation/role of energy storage devices and their suitability for different applications (e.g. grid services, electrical vehicles, etc.)
- Parameters that are describing the performance and lifetime behaviour of batteries
- Good knowledge about the performance (static and dynamic) behaviour of batteries and its dependence on the operating conditions (temperature, load current, etc.)
- Different performance modelling approaches for batteries, their parameterization and application
- Understand the degradation process of lithium-ion batteries from a macroscopic perspective
- Methods for lifetime estimation of lithium-ion batteries

SKILLS

- Derive/obtain battery parameters based on datasheet and/or laboratory measurements
- Development and parametrization of battery performance models
- Development and parametrization of simple battery lifetime models

COMPETENCES

- Evaluation of the suitability of different energy storage technologies for various applications
- Mapping the relationship between battery performance and the operating conditions
- Selection and parametrization of battery models based on specific requirements
- Design laboratory tests for battery model parametrization

TYPE OF INSTRUCTION

The course is planned and organized in close interaction with the on-going research and development activities at AAU Energy and by following the well-established PBL approach.

All lectures will include a mixture of class teaching, exercises, reflections and lecturer/supervisor feedback. Furthermore, the students will develop a mini-project using the concepts presented during the lectures.

EXTENT AND EXPECTED WORKLOAD

Since it is a 5 ECTS course module, the work load is expected to be 150 hours for the student.

EXAM

EXAMS

Name of exam	Performance Assessment and Modelling of Batteries
Type of exam	Oral exam based on a project There will be an oral examination based on the submitted mini-project. The mini-projects can be developed in groups of 2-3 persons; however, the submission and evaluation will be individual.
ECTS	5
Permitted aids	With certain aids: For more information about permitted aids, please visit the course description in Moodle.
Assessment	7-point grading scale
Type of grading	Internal examination
Criteria of assessment	The criteria of assessment are stated in the Examination Policies and Procedures

FACTS ABOUT THE MODULE

Danish title	Ydelsesvurdering og modellering af batterier
Module code	N-EE-K3-24B
Module type	Course
Duration	1 semester
Semester	Autumn
ECTS	5
Language of instruction	English
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg, Campus Esbjerg
Responsible for the module	Tamas Kerekes, Matthias Mandø

ORGANISATION

Study Board	Study Board of Energy
Department	Department of Energy
Faculty	The Faculty of Engineering and Science

BATTERY ENERGY STORAGE SYSTEMS

2024/2025

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

The module is based on knowledge achieved when studying the 2nd semester on the Master of Science in Energy Engineering with an electrical or thermal specialisation or Master of Science in Sustainable Energy Engineering with specialisation in Offshore Energy Systems or similar.

LEARNING OBJECTIVES

KNOWLEDGE

- Have knowledge about different battery energy storage technologies (e.g. lithium-ion, lead acid etc.) and understand their operation principles
- Understand the operation/role of energy storage devices and their suitability for different applications (e.g., grid services, electrical vehicles etc.)
- Have good knowledge about the performance (static and dynamic) behaviour of batteries and its dependence on the operating conditions (temperature, load current etc.). Gain experience about different performance and thermal modelling approaches and model parameterization techniques using digital platforms
- Understand the degradation process of lithium-ion and lead-acid batteries from a macroscopic perspective. Gain knowledge about different methods for lifetime estimation of batteries using digital platforms
- Gain practical knowledge about testing of lead-acid and lithium-ion batteries in laboratory

SKILLS

- Be able to evaluate the suitability of different energy storage technologies for various applications
- Be able to test different battery technologies in laboratory and to measure their most important electrical and thermal parameters
- Be able to derive various battery parameters from laboratory measurements

COMPETENCES

- Be able to develop performance models for different battery technologies based on various requirements using digital platforms
- Independently be able to develop procedures for laboratory testing of batteries

TYPE OF INSTRUCTION

The course will be planned and organised in close interaction with on going research and development activities at the Department of Energy and its collaborators. All modules include exercises focusing on the presented material; some exercises will be performed using MATLAB and Simulink. Moreover, some exercises will be carried out on programmable battery test stations. Finally, different e-learning activities may be used.

EXTENT AND EXPECTED WORKLOAD

Since it is a 5 ECTS course module, the work load is expected to be 150 hours for the student.

EXAM

EXAMS

Name of exam	Battery Energy Storage Systems
Type of exam	Oral exam based on a project

	Each student should submit all the laboratory exercises in the form of a report. The oral examination will be based on the submitted report.
ECTS	5
Permitted aids	With certain aids: For more information about permitted aids, please visit the course description in Moodle.
Assessment	7-point grading scale
Type of grading	Internal examination
Criteria of assessment	The criteria of assessment are stated in the Examination Policies and Procedures

FACTS ABOUT THE MODULE

Danish title	Energilagringssystemer til batteri
Module code	N-EE-K3-11B
Module type	Course
Duration	1 semester
Semester	Autumn
ECTS	5
Language of instruction	English
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg, Campus Esbjerg
Responsible for the module	Matthias Mandø

ORGANISATION

Study Board	Study Board of Energy
Department	Department of Energy
Faculty	The Faculty of Engineering and Science

FUTURE POWER SYSTEM IN DENMARK

2024/2025

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

The module is based on knowledge achieved when studying the 2nd semester on the Master of Science in Energy Engineering with an electrical specialisation or similar.

LEARNING OBJECTIVES

KNOWLEDGE

- Have knowledge and understanding within the technique of the grid and system challenges that the electricity power system in Denmark is expected to face in the future in terms of design and system operation.

SKILLS

- Be able to explain the grid technique and systemic challenges of electricity supply in Denmark in the future facing, both design and / or terms of system operation
- Be able to analyse and assess the structure, composition, interaction and mutual influence between the relevant parts of the electricity grid and power system in one or more of the fields distribution, transmission, production and consumption using digital platforms
- Be able to use and through that become familiar with earlier learned electrical power system theory
- Be able to identify, evaluate, and argue for changes in existing power system facilities taking into consideration high personal security, high continuity of supply and finance

COMPETENCES

- Be able to explain the grid technique and systemic challenges of electricity supply in Denmark in the future facing, both design and / or terms of system operation
- Be able to analyse and assess the structure, composition, interaction and mutual influence between the relevant parts of the electricity grid and power system in one or more of the fields distribution, transmission, production and consumption using digital platforms
- Be able to use and through that become familiar with earlier learned electrical power system theory
- Be able to identify, evaluate, and argue for changes in existing power system facilities taking into consideration high personal security, high continuity of supply and finance

TYPE OF INSTRUCTION

The course will include lectures; guest-lectures, e-learning activites; team work; web-conferences/question time; and conference. With starting point in Denmark's existing electrical power system, and known political objectives and decisions for Denmark (at regional or national level), students must analyse their way through to a concrete solution for the future electricity supply in Denmark, based on the course's theme and within a more defined, self-elected project focus.

EXTENT AND EXPECTED WORKLOAD

Since it is a 5 ECTS course module, the work load is expected to be 150 hours for the student.

EXAM

EXAMS

Name of exam	Future Power System in Denmark
Type of exam	Oral exam based on a project

	Oral examination based on a delivered mini-project/test report (individual or made in groups).
ECTS	5
Permitted aids	With certain aids: For more information about permitted aids, please visit the course description in Moodle.
Assessment	7-point grading scale
Type of grading	Internal examination
Criteria of assessment	The criteria of assessment are stated in the Examination Policies and Procedures

FACTS ABOUT THE MODULE

Danish title	Fremtidens el-forsyning i Danmark
Module code	N-EE-K3-18B
Module type	Course
Duration	1 semester
Semester	Autumn
ECTS	5
Language of instruction	English
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg, Campus Esbjerg
Responsible for the module	Tamas Kerekes, Matthias Mandø

ORGANISATION

Study Board	Study Board of Energy
Department	Department of Energy
Faculty	The Faculty of Engineering and Science

NON-LINEAR CONTROL AND MULTI-BODY SYSTEMS

2024/2025

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Be able to carry out kinematic analysis of multi-body systems
- Be able to model multi-body dynamical systems using selected methods
- Be able to develop complete system models that include actuators and possible hard non-linearities
- Be able to analyse systems using linearization-, Lyapunov- and phase plane methods
- Be able to design non-linear controllers for considered systems in the presence on uncertain and possibly varying system parameters

SKILLS

- Be able to establish various types models for non-linear system, including multi-body and actuator models
- Be able to judge the usefulness of the different analyses and design methods
- Be able to apply the learned knowledge to analyse and study non-linear dynamical systems
- Be able to design selected types of non-linear controllers
- Be able to implement selected types of non-linear controllers

COMPETENCES

- Independently be able to describe and analyse non-linear systems
- Independently be able to design considered non-linear controllers
- Independently be able to continue own development within the field of non-linear systems analysis and control

TYPE OF INSTRUCTION

The programme is based on a combination of academic, problem oriented and interdisciplinary approaches and organised based on the following types of instruction that combine skills and reflection:

- lectures
- class teaching
- project work
- workshops
- exercises (individually and in groups)
- teacher feedback
- professional reflection
- portfolio work
- laboratory work
- and various e-learning activities

The form(s) of teaching will be determined and described in connection with the planning of the semester. The description will account for the form(s) of teaching and may be accompanied by an elaboration of the roles of the participants.

EXTENT AND EXPECTED WORKLOAD

Since it is a 5 ECTS course module, the work load is expected to be 150 hours for the student.

EXAM

EXAMS

Name of exam	Non-linear Control and Multi-body Systems
Type of exam	Written or oral exam
ECTS	5
Permitted aids	With certain aids: For more information about permitted aids, please visit the course description in Moodle.
Assessment	7-point grading scale
Type of grading	Internal examination
Criteria of assessment	The criteria of assessment are stated in the Examination Policies and Procedures

ADDITIONAL INFORMATION

This course is taught to the 1st semester MSc students at the Mechatronic Control Engineering specialisation and is offered as an elective course at the 3rd semester of all other specialisations. Students of the Mechatronic Control Engineering specialisation cannot elect the module again.

FACTS ABOUT THE MODULE

Danish title	Ikke-lineær regulering og flerlegeme systemer
Module code	N-EE-K1-11A
Module type	Course
Duration	1 semester
Semester	Autumn
ECTS	5
Language of instruction	English
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg, Campus Esbjerg
Responsible for the module	Tamas Kerekes, Matthias Mandø

ORGANISATION

Study Board	Study Board of Energy
Department	Department of Energy
Faculty	The Faculty of Engineering and Science

SYSTEM IDENTIFICATION AND DIAGNOSIS

2024/2025

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Have comprehension of the fundamental principles of typical methods of system identification
- Have comprehension of the fundamental concepts, terms and methodologies of abnormal diagnosis
- Have comprehension of some typical model-based and signal-based diagnosis

SKILLS

- Be able to apply the learned knowledge to handle some simple system identification problems under assistance of a commercial software
- Be able to apply and analyse different diagnosis methods

COMPETENCES

- Independently be able to define and analyse scientific problems within the area of system identification and diagnosis using digital platforms
- Independently be able to be a part of professional and interdisciplinary development work within the area of system identification and diagnosis

TYPE OF INSTRUCTION

The course is taught by a mixture of lectures, workshops, exercises, mini-projects and self-studies, including e-learning activities.

EXTENT AND EXPECTED WORKLOAD

Since it is a 5 ECTS course module, the work load is expected to be 150 hours for the student.

EXAM

EXAMS

Name of exam	System Identification and Diagnosis
Type of exam	Oral exam
ECTS	5
Permitted aids	With certain aids: For more information about permitted aids, please visit the course description in Moodle.
Assessment	7-point grading scale
Type of grading	Internal examination
Criteria of assessment	The criteria of assessment are stated in the Examination Policies and Procedures

FACTS ABOUT THE MODULE

Danish title	Systemidentifikation og diagnosticering
Module code	N-SEE-K1-3B
Module type	Course
Duration	1 semester
Semester	Autumn
ECTS	5
Language of instruction	English
Empty-place Scheme	Yes
Location of the lecture	Campus Esbjerg, Campus Aalborg
Responsible for the module	Tamas Kerekes, Matthias Mandø

ORGANISATION

Study Board	Study Board of Energy
Department	Department of Energy
Faculty	The Faculty of Engineering and Science

RELIABILITY OF POWER ELECTRONICS BASED POWER SYSTEMS

2024/2025

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

The module is based on knowledge achieved during BSc programme on the power system operation and control, power electronics and basic probability theory.

Modern power electric based power systems (PEPS) are facing new challenges in terms of reliable planning and operation due to proliferation of power electronic converters. The course is aimed at providing an in-depth introduction to the reliability modeling, assessment and enhancement approaches in PEPS. The basic principles of reliability evaluation along with their application, current practices and solution methods in PEPS will be discussed.

LEARNING OBJECTIVES

KNOWLEDGE

- Fundamental concepts of reliability Engineering
- Techniques used in engineering system risk assessment
- Basic concepts of adequacy and security in electric power systems
- Generating capacity reliability assessment
- Composite generation and transmission system reliability evaluation
- Application of risk evaluation in transmission developing planning, transmission operation planning, and generation source planning
- Distribution system reliability evaluation
- Structural reliability and stress strength analysis
- Introduction to converter reliability prediction
- Model-based Reliability modeling in power electronic based power systems
- Reliability enhancement in PEPS

SKILLS

- Learning probabilistic approaches application to power systems
- Analysing the reliability of engineering systems
- Assessing the reliability of modern power systems
- Probabilistic design and maintenance planning approaches for modern power systems

COMPETENCES

- Understanding the fundamental of system reliability engineering
- Understanding the concepts of modern power system reliability
- Exposure to probabilistic technique applications to modern power system problems
- Exposure to probabilistic technique applications to power electronics based power system problems

TYPE OF INSTRUCTION

The Master's programme is based on a combination of academic, problem oriented and interdisciplinary approaches and organised based on the following types of instruction that combine skills and reflection:

- Lectures
- Class teaching
- Project work
- Exercises (individually and in groups)
- Digital learning in different ways including flipped class room, blended learning, game or quiz
- Supervisor feedback
- Professional reflection

- Portfolio work

EXTENT AND EXPECTED WORKLOAD

Since it is a 5 ECTS course module, the work load is expected to be 150 hours for the student.

EXAM

EXAMS

Name of exam	Reliability of Power Electronics Based Power Systems
Type of exam	Written exam The student will be evaluated based on the exercises and paper-based final exam. There will be 5 exercises being done in groups of 2-3 persons.
ECTS	5
Permitted aids	With certain aids: For more information about permitted aids, please visit the course description in Moodle.
Assessment	7-point grading scale
Type of grading	Internal examination
Criteria of assessment	The criteria of assessment are stated in the Examination Policies and Procedures

FACTS ABOUT THE MODULE

Danish title	Pålidelighed af elektriske anlæg baseret på effektelektronik
Module code	N-EE-K3-25B
Module type	Course
Duration	1 semester
Semester	Autumn
ECTS	5
Language of instruction	English
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg, Campus Esbjerg
Responsible for the module	Tamas Kerekes, Matthias Mandø

ORGANISATION

Study Board	Study Board of Energy
Department	Department of Energy
Faculty	The Faculty of Engineering and Science

ARTIFICIAL INTELLIGENCE IN ENERGY SYSTEMS

2024/2025

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

Programming experience in MATLAB or Python is recommended.

LEARNING OBJECTIVES

KNOWLEDGE

- Have knowledge about the progress and state-of-the-art of AI-based applications in energy sector
- Have knowledge about basic machine/deep learning approaches and how to apply them (supervised learning, unsupervised learning, reinforcement learning, anomaly detection)
- Have knowledge about different machine learning models and relevant variants (ANN, decision trees, SVM (Support Vector Machine), …)
- Have knowledge about typical data-driven implementation procedures including data collection and pre-processing techniques, with end-to-end toolbox creating good training data, feature extraction

SKILLS

- Be able to use different machine learning approaches in electrical engineering applications
- Be able to train machine learning models and prepare training data
- Be able to analyse and understand the training results
- Be able to apply cutting-edge data-driven toolboxes for field applications.

COMPETENCES

- Be able to have a data-driven thinking and know when and why using AI for energy applications
- Be able to define a machine learning problem, gather the relevant data
- Be able to implement the machine learning models and use fundamental libraries for machine learning
- Be able to understand how to process training data and analyse the obtained model output

TYPE OF INSTRUCTION

The course is taught by a mixture of lectures, exercises, and e-learning activities.

EXTENT AND EXPECTED WORKLOAD

Since it is a 5 ECTS course module, the work load is expected to be 150 hours for the student.

EXAM

EXAMS

Name of exam	Artificial Intelligence in Energy Systems
Type of exam	Oral exam The exam is based on a report submitted by individual students or small groups of students.
ECTS	5
Permitted aids	With certain aids: For more information about permitted aids, please visit the course description in Moodle.
Assessment	7-point grading scale

Type of grading	Internal examination
Criteria of assessment	The criteria of assessment are stated in the Examination Policies and Procedures

FACTS ABOUT THE MODULE

Danish title	Kunstig intelligens i energisystemer
Module code	N-EE-K3-27
Module type	Course
Duration	1 semester
Semester	Autumn
ECTS	5
Language of instruction	English
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg
Responsible for the module	Tamas Kerekes

ORGANISATION

Study Board	Study Board of Energy
Department	Department of Energy
Faculty	The Faculty of Engineering and Science