AALBORG UNIVERSITET

STUDIEORDNING FOR KANDIDATUDDANNELSEN (MSC) I INTELLIGENTE PÅLIDELIGE SYSTEMER 2014

CIVILINGENIØR
ESBJERG

MODULER SOM INDGÅR I STUDIEORDNINGEN

INDHOLDSFORTEGNELSE

SYSTEM IDENTIFICATION AND ESTIMATION

2018/2019

PREREQUISITE/RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

Bachelor of Science in EE, CSE or alike.

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

Content

The project unit focuses on the identification and/or estimation of engineering systems for the control design purpose. The considered systems can come from (petro-)chemical process industry, offshore oil and gas industry, mechanical systems, robots or other engineering systems with the requirements for identification and/or estimation. The considered problem should be formulated and analyzed, then some proper identification/estimation method needs to be selected and implemented. The designed/constructed system is assessed through simulation and practical test as well.

LEARNING OBJECTIVES

KNOWLEDGE

- Have knowledge and comprehension for the system identification techniques.
- Have fundamental knowledge and comprehension of probability, statistics and stochastic processes.
- Have knowledge of the phases that an engineering project go through
- Understand various theories and methods applied in problem based learning and group organized project work.

SKILLS

- Be able to choose different system identification/estimation methods and algorithms for different identification and/or estimation engineering problems.
- Be able to evaluate the results using the probabilistic and/or statistic sense.
- Be able to verify the analytical and numerical approaches by means of simple laboratory experiments
- Be able to communicate scientific results by use of papers, posters and oral presentations
- Are able to plan and take part in a small group of students working on a problem based project
- Can reflect on experiences obtained through problem based learning and group organized project work
- Can discuss various approaches to project management.

COMPETENCES

- Be able to control the working and development process within the project theme, and be able to develop new solutions within identification/estimation technology
- Independently be able to define and analyze scientific problems of identification /estimation for engineering systems, and based on that make and state the reasons for decisions made for selecting corresponding method.
- Independently be able to continue own development in competences and specialization
- Can find, evaluate and reference literature within the professional field
- Can apply internationally recognized principles for acknowledging and citing work of others

TYPE OF INSTRUCTION

Project work.

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	System Identification and Estimation
Type of exam	Oral exam based on a project
ECTS	15
Assessment	7-point grading scale
Type of grading	External examination
Criteria of assessment	As stated in the Joint Programme Regulations. http://www.engineering.aau.dk/uddannelse/studieadministration/

ADDITIONAL INFORMATION

Project on 1st Semester Intelligent Reliable Systems (IRS).

FACTS ABOUT THE MODULE

Danish title	Systemidentifikation og estimering
Module code	N-IRS-K1-1
Module type	Project
Duration	1 semester
Semester	Autumn
ECTS	15
Empty-place Scheme	Yes
Location of the lecture	Campus Esbjerg
Responsible for the module	Petar Durdevic Løhndorf
Time allocation for external examiners	B

ORGANISATION

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

STOCHASTIC PROCESSES

2018/2019

PREREQUISITE/RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

Solid knowledge in probability, statistics, linear algebra, Fourier theory, and programming

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

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

SKILLS

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

COMPETENCES

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

TYPE OF INSTRUCTION

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

- Lectures
- Classroom instruction
- Project work
- Workshops
- Exercises (individually and in groups)
- Teacher feedback
- Reflection
- Portfolio work

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	Stochastic Processes
Type of exam	Written or oral exam
ECTS	5
Assessment	7-point grading scale
Type of grading	Internal examination
Criteria of assessment	As stated in the Joint Programme Regulations. http://www.engineering.aau.dk/uddannelse/studieadministration/

FACTS ABOUT THE MODULE

Danish title	Stokastiske processer
Module code	N-IRS-K1-2
Module type	Course
Duration	1 semester
Semester	Autumn
ECTS	5
Empty-place Scheme	Yes
Location of the lecture	Campus Esbjerg
Responsible for the module	Carles Navarro Manchon

ORGANISATION

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

SYSTEM IDENTIFICATION AND DIAGNOSIS

2018/2019

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.

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
Assessment	7-point grading scale
Type of grading	Internal examination
Criteria of assessment	As stated in the Joint Programme Regulations. http://www.engineering.aau.dk/uddannelse/studieadministration/

ADDITIONAL INFORMATION

This course is taught to the 1st semester MSc students at the Offshore Energy Systems specialisation and is offered as an elective course at the 3rd semester of the Energy Engineering specialisations as well as the Process Engineering and

Combustion Technology specialisation. Students of the Offshore Energy Systems specialisation cannot elect the module again.

FACTS ABOUT THE MODULE

Danish title	Systemidentifikation og diagnosticering
Module code	N-SEE-K1-3
Module type	Course
Duration	1 semester
Semester	Autumn
ECTS	5
Empty-place Scheme	Yes
Location of the lecture	Campus Esbjerg, Campus Aalborg
Responsible for the module	Zhenyu Yang, Per Johansen, Seyed Mohsen Nourbakhsh Soltani

ORGANISATION

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

ADVANCED MODELING OF DYNAMIC SYSTEMS

2018/2019

PREREQUISITE/RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

Mathematics and physics from a relevant Bachelor of Science.

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

Purpose

- to contribute to students' attainment of knowledge and comprehension of systematic methods for modelling complex mechanical structures and non-rigid (flexible) mechanical structures, and further to achieve knowledge and comprehension about advanced dynamics equations and solutions for motion of systems with rigid or non-rigid bodies.
- to contribute to students' attainment of knowledge and comprehension of fluid power systems and components and enable them to analyze and model such systems.

Content

Advanced mechanic systems:

- Planar and spatial rigid body kinematics
- Cartesian coordinates and Euler parameters
- Transformation matrices
- Cinematic constraints for plane and spatial joints and actuators
- Cinematic constraints for a cinematically determined system
- Position, velocity and acceleration analysis
- Energy methods
- Lagrange multipliers
- Reaction forces and torques
- Rigid body motion (equations of motion) for planar and spatial cases
- Modelling flexible mechanical bodies and joints
- Advanced friction models

Fluid power:

- Introduction to dynamic hydraulic systems
- Properties of the pressure media and the stiffness influence on the system dynamics
- Continuity and momentum equations
- Systematic approach for deriving dynamic lumped parameter models of system components such as: cylinders, pumps, motors, valves and flow and pressure regulating components
- Flow forces in valves
- Fluid power (servo) drives
- Modelling and simulation of selected characteristic component(s)
- Examples of control system design for fluid power systems

LEARNING OBJECTIVES

KNOWLEDGE

- Have knowledge and comprehension for complex mechanical structures
- Have knowledge of modelling non-rigid (flexible) mechanical structures and friction between two moving parts.
- Have knowledge and comprehension for advanced dynamics for motion of systems with rigid or non-rigid bodies.
- Have knowledge and comprehension for 3-dimensional kinematic problems.
- Have comprehension of the characteristics of the pressure media and its influence on the system dynamics

SKILLS

- Be able to apply systematic methods for modelling complex mechanical structures dynamically in both planar and spatial cases.
- Be able to analyze and model the dynamics of fluid power components and systems
- Be able to judge the usefulness of the set up methods
- Be able to relate the methods to applications in the industry

COMPETENCES

- Independently be able to define and analyze scientific problems within the area of advanced mechanic systems
- Independently be able to be a part of professional and interdisciplinary development work within fluid power and advanced mechanic systems.

TYPE OF INSTRUCTION

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

- Lectures
- Classroom instruction
- Project work
- Workshops
- Exercises (individually and in groups)
- Teacher feedback
- Reflection
- Portfolio work

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 Modeling of Dynamic Systems
Type of exam	Written or oral exam
ECTS	5
Assessment	7-point grading scale
Type of grading	Internal examination
Criteria of assessment	As stated in the Joint Programme Regulations. http://www.engineering.aau.dk/uddannelse/studieadministration/

ADDITIONAL INFORMATION

Elective course
On this semester one course must be chosen out of three elective courses (total: 5 ECTS).

FACTS ABOUT THE MODULE

Danish title	Avanceret modellering af dynamiske systemer
Module code	N-IRS-K1-4

Module type	Course
Duration	1 semester
Semester	Autumn
ECTS	5
Empty-place Scheme	Yes
Location of the lecture	Campus Esbjerg
Responsible for the module	Petar Durdevic Løhndorf, Simon Pedersen

ORGANISATION

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

STRUCTURAL MECHANICS AND DYNAMICS

2018/2019

PREREQUISITE/RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

Electronic and/or mechanic engineering on BSc level.

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Understand how kinematics of different structural elements are related to general continuum mechanics
- Have an understanding of fundamental properties of structural systems with emphasis on their impact on the dynamic response
- Have knowledge about fundamental theories and methods for analysis of dynamic structural response
- Have an understanding of the solution procedure in Finite Element Analysis of linear elastic dynamic problems
- Have a basic knowledge and understanding of experimental work related to dynamic testing of structures

SKILLS

- Use correct terminology for structural dynamic analysis
- Based on general continuum mechanics, be able to formulate a model for a given structural problem and based on the assumed kinematics, to establish a finite element formulation with the aid of the principle of virtual work
- Be able to analyze the dynamic response of single-degree-of-freedom systems
- Be able to analyze the dynamic response of structures in time domain and frequency domain
- Be able to conduct modal analysis of structures
- Develop and implement a Finite Element Software code for analyzing the dynamic response of a given structure
- Be able to plan and set up a test for determining dynamic structural response

COMPETENCES

- Be able to analyze the dynamic response of a structure
- Be able to select appropriate analysis methods for the analysis of dynamic structural response
- Be able to compare results obtained from different analysis methods and be able to judge the quality of the results
- Be able to quantify errors associated with different types of analysis and evaluate the methods regarding assumptions and simplifications

TYPE OF INSTRUCTION

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

- Lectures
- Classroom instruction
- Project work
- Workshops
- Exercises (individually and in groups)
- Teacher feedback
- Reflection
- Portfolio work

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	Structural Mechanics and Dynamics
Type of exam	Written or oral exam
ECTS	5
Assessment	7-point grading scale
Type of grading	Internal examination
Criteria of assessment	As stated in the Joint Programme Regulations. http://www.engineering.aau.dk/uddannelse/studieadministration/

ADDITIONAL INFORMATION

Elective course
On this semester one course must be chosen out of three elective courses (total: 5 ECTS).

FACTS ABOUT THE MODULE

Danish title	Strukturel mekanik og dynamik
Module code	N-IRS-K1-6
Module type	Course
Duration	1 semester
Semester	Autumn
ECTS	5
Empty-place Scheme	Yes
Location of the lecture	Campus Esbjerg
Responsible for the module	Martin Dalgaard Ulriksen

ORGANISATION

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

KALMAN FILTER THEORY AND ITS APPLICATION

2018/2019

PREREQUISITE/RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

Numerical methods, probability, statistics and stochastic processes.

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

Purpose

- to contribute to students' attainment of knowledge and comprehension of Kalman filter theory.
- to contribute to students' attainment of knowledge and comprehension of how to apply Kalman filter theory for engineering problems, such as abnormal diagnosis and multiple target tracking etc.

Content

Conventional Kalman filter theory:

- Scale Kalman filter
- Vector-based Kalman filter
- Convergence and preconditions

Extended Kalman filter theory:

- Extended Kalman filter (EKF)
- Uncended Kalman filter (UKF)
- Multi-mode Kalman filter

Application of KF theory

- Fault detection using KF theory
- Fault diagnosis using KF theory
- Multiple target tracking
- Multi-mode system estimation

LEARNING OBJECTIVES

KNOWLEDGE

- Have knowledge and comprehension for Kalman filter theory
- Have knowledge and comprehension for extended Kalman filter techniques
- Have knowledge and comprehension for vector-based Kalman filter theory.
- Have comprehension of the application of Kalman filter theory to abnormal scenario diagnosis
- Have comprehension of the application of Kalman filter theory to multiple target tracking

SKILLS

- Be able to apply Kalman filter theory for state estimation problem in the presence of noises.
- Be able to apply Kalman filter theory for abnormal diagnosis problem
- Be able to apply Kalman filter theory for multiple target tracking problem
- Be able to judge the usefulness of the set up methods
- Be able to relate the methods to applications in the industry

COMPETENCES

- Independently be able to define and analyze scientific problems using Kalman filter theory
- Independently be able to apply Kalman filter theory for different engineering problems

TYPE OF INSTRUCTION

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

- Lectures
- Classroom instruction
- Project work
- Workshops
- Exercises (individually and in groups)
- Teacher feedback
- Reflection
- Portfolio work

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	Kalman Filter Theory and its Application
Type of exam	Written or oral exam
ECTS	5
Assessment	7-point grading scale
Type of grading	Internal examination
Criteria of assessment	As stated in the Joint Programme Regulations. http://www.engineering.aau.dk/uddannelse/studieadministration/

ADDITIONAL INFORMATION

Elective course
On this semester one course must be chosen out of three elective courses (total: 5 ECTS).

FACTS ABOUT THE MODULE

Danish title	Kalman filterteori og anvendelse
Module code	N-IRS-K1-5
Module type	Course
Duration	1 semester
Semester	Autumn
ECTS	5
Empty-place Scheme	Yes
Location of the lecture	Campus Esbjerg
Responsible for the module	Birgitte Bak-Jensen

ORGANISATION

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

FAULT DIAGNOSIS AND RELIABILITY ANALYSIS

2018/2019

PREREQUISITE/RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

1st Semester

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

Purpose
The purpose of the project unit is to contribute to students' attainment of knowledge about fault detection, diagnosis and relevant reliability analysis of engineering systems

Content
The project is based on a problem to monitor a process system, which can be a chemical process, mechanical system, or any other safety-critical systems. The reliability of the considered system as well as individual components should be analyzed and assessed using the probabilistic methods. The strategies and methods for Fault Detection and Diagnosis (FDD) should be determined for the considered system by taking some intelligent methods into consideration. The chosen FDD solution has to be implemented on a real-time platform and tested, either by the computer simulations or a dedicated hardware

LEARNING OBJECTIVES

KNOWLEDGE

- Have knowledge and comprehension for how to design, analyze and model different fault diagnosis systems for different typical engineering systems
- Have knowledge and comprehension of fundamental reliability analysis and modelling

SKILLS

- Be able to apply probabilistic methods for reliability modelling, analysis and assessment.
- Be able to apply different fault diagnosis methods for developing monitoring and surveillance system.
- Be able to verify the analytical and numerical approaches either by means of laboratory experiments or simulation study

COMPETENCES

- Be able to control the working and development process within the project theme, and be able to develop new solutions within monitoring and surveillance system.
- Independently be able to define and analyze monitoring/diagnosis problems from the reliability point of view, and based on that make and state the reasons for decisions made for method selection.
- Independently be able to continue own development in competences and specialization

TYPE OF INSTRUCTION

Project work.

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	Fault Diagnosis and Reliability Analysis
Type of exam	Oral exam based on a project
ECTS	15
Assessment	7-point grading scale
Type of grading	External examination
Criteria of assessment	As stated in the Joint Programme Regulations. http://www.engineering.aau.dk/uddannelse/studieadministration/

ADDITIONAL INFORMATION

Project Module on 2nd Semester Intelligent Reliable Systems (IRS).

FACTS ABOUT THE MODULE

Danish title	Fejldiagnosticering og pålidelighedsanalyse
Module code	N-IRS-K2-1
Module type	Project
Duration	1 semester
Semester	Spring
ECTS	15
Empty-place Scheme	Yes
Location of the lecture	Campus Esbjerg
Responsible for the module	Zhenyu Yang
Time allocation for external examiners	B

ORGANISATION

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

CONTROL AND SURVEILLANCE PROCESSES AND SYSTEMS

2018/2019

PREREQUISITE/RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

Control theory and digital microprocessors.

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

Objective

- to contribute to students' attainment of knowledge and comprehension of typical industrial automation systems
- to contribute to students' attainment of knowledge and comprehension of basic nonlinear control theory

Purpose

The course purpose consists of two parts:

- To contribute to students' attainment of comprehension of some typical industrial control and surveillance processes/systems, such as control of AC-machines, PLC programming and implementation and SCADA systems.
- To contribute to students' attainment of comprehension of fundamental knowledge of non-linear control systems and the feedback linearization design method

Content

Industrial automation systems:

- Introduction to industrial automation systems
  - Overview of typical energy- industrial automation systems
- Control of AC machines
  - AC machine models, e.g., dynamic models, space-vector models
  - AC machine stationary characteristics
    - Motoring vs. generating mode
    - Speed-torque-current-voltage-flux characteristics
  - Induction machine control
    - Variable frequency operation (V/Hz control)
    - Small-signal stability analysis during V/Hz control
    - Voltage-vector control
    - Compensation for resistive voltage drops
    - Load compensation (slip frequency)
  - Permanent-magnet machine control
    - Torque production mechanisms
    - Rotor-flux oriented control principles
    - Current control
    - Principles of field-weakening operation
- Programmable Logic Controllers (PLC's)
  - Architecture of PLC systems, includes the microprocessor unit, I/O modules, communications and user interface
  - PLC programming using IEC 61131-3 standard
  - Introduction to Programmable Automation Controllers (PAC's)
  - Examples of vendor PLC's and fieldbus interfaces to PLC's
- Supervisory Control And Data Acquisition (SCADA) systems
  - System concepts and features
    - Human Machine Interface (HMI)
    - Remote Terminal Unit (RTU)
    - Supervisory station
    - Communication infrastructure and methods
  - SCADA architectures, e.g., monolithic, distributed, networked configurations

    - Reliability and security issues
        - Redundancy
        - Reliability statistic calculation
        - Network security
    - Application examples of SCADA in energy systems

Nonlinear control theory

- Introduction to nonlinear control
- Phase plane analysis
- Lyapunov stability theory
    - Lyapunov Stability
    - Linearization and local stability
    - Lyapunov's direct method
    - Stabilization control design based on Lyapunov method
- Feedback linearization
    - Lie derivatives and Lie brackets
    - Diffeomorphisms and state transformations
    - Frobenius theorem
    - Input-state linearization of SISO systems
    - Input-output linearization of SISO systems

LEARNING OBJECTIVES

KNOWLEDGE

- Have comprehension of some typical industrial automation processes/systems including the control of AC-machines, PLC systems and SCADA systems
- Have comprehension of fundamental concepts and terms of nonlinear control theory.
- Have comprehension of Lyapunov's methods for stability analysis and stabilization control design.

SKILLS

- Be able to apply the learned knowledge to handle some small-sized industrial automation systems.
- Be able to apply the feedback linearization method for non-linear control design.
- Be able to judge the usefulness of the set up methods
- Be able to relate the methods to applications in the industry

COMPETENCES

- Independently be able to define and analyze scientific problems within the area of control and surveillance systems.
- Independently be able to be a part of professional and interdisciplinary development work within the area of control and surveillance systems.

TYPE OF INSTRUCTION

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

- Lectures
- Classroom instruction
- Project work
- Workshops
- Exercises (individually and in groups)
- Teacher feedback
- Reflection
- Portfolio work

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 and Surveillance Processes and Systems
Type of exam	Written or oral exam
ECTS	5
Assessment	7-point grading scale
Type of grading	Internal examination
Criteria of assessment	As stated in the Joint Programme Regulations. http://www.engineering.aau.dk/uddannelse/studieadministration/

FACTS ABOUT THE MODULE

Danish title	Regulerings og overvågningsprocesser og -systemer
Module code	N-IRS-K2-2
Module type	Course
Duration	1 semester
Semester	Spring
ECTS	5
Empty-place Scheme	Yes
Location of the lecture	Campus Esbjerg
Responsible for the module	Seyed Mohsen Nourbakhsh Soltani

ORGANISATION

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

FAULT DETECTION AND DIAGNOSIS TECHNIQUES

2018/2019

PREREQUISITE/RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

Probability, statistics and stochastic processes, system identification and estimation

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

Purpose

- To contribute to students' attainment of comprehension of some typical fault detection and diagnosis techniques.

Content

- Fundamental concepts, terms and principles of FDD
- Fault modelling and analysis
  - Fault types and classification
  - Fault modelling
  - Fault delectability
  - Fault diagnosability
- Residual generation (I): Observer based FDD methods for deterministic systems
  - Review of observer theory
  - Fault detection using single observer
  - Fault diagnosis using a bank of observers
- Residual generation (II): Kalman filter based FDD methods for stochastic systems
  - Review of probability and stochastic processes
  - Kalman filter theory
  - Extended Kalman filter
  - Fault detection using single Kalman filter
  - Fault diagnosis using a bank of Kalman filters (Multiple Model (MM) method)
  - Fault diagnosis using a bank interactive Kalman filters (Interactive Multiple Model (IMM) method)
  - Fault diagnosis using a two-stage Kalman filter for additive and multiplicative faults
- Robust residual generation (I): Unknown Input Observer (UIO) method
  - (complete) Disturbance decoupling principle
  - UIO theory
  - Robust FDD using UIO method
- Robust residual generation (II): Robust filtering method
  - Disturbance attenuation principle
  - Modelling uncertainties
  - Introduction to robust filtering theory (H_infty optimal control theory)
  - Robust FDD using H_infty filtering method
- Residual evaluation
  - Simple voting techniques
  - Statistical testing approaches
  - Likelihood function methods
  - Probabilities of false alarm and miss
- FDD using Parity space approaches
  - Delectability and diagnosability
  - Parity space methods for FDD
- Parameter estimation based FDD methods
  - Parametric fault characteristics
  - FDD using parameter estimation (least-square methods)
  - FDD using recursive system identification methods
- Signal-based (model-free) FDD methods
  - FDD using spectrum analysis
  - FDD using short-timed Fourier transform and wavelet transform
  - FDD using some artificial intelligence methods

LEARNING OBJECTIVES

KNOWLEDGE

- Have comprehension of some typical model-free fault detection and diagnosis methods
- Have comprehension of some typical model-based fault detection and diagnosis methods

SKILLS

- Are able to apply the learned knowledge to handle some fault detection and diagnosis problems.
- Are able to judge the usefulness of the set up methods
- Are able to relate the methods to applications in the industry

COMPETENCES

- Independently be able to define and analyze scientific problems within the area of fault detection and diagnosis.
- Independently be able to be a part of professional and interdisciplinary development work within the area of fault detection and diagnosis.

TYPE OF INSTRUCTION

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

- Lectures
- Classroom instruction
- Project work
- Workshops
- Exercises (individually and in groups)
- Teacher feedback
- Reflection
- Portfolio work

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 Detection and Diagnosis Techniques
Type of exam	Written or oral exam
ECTS	5
Assessment	7-point grading scale
Type of grading	Internal examination
Criteria of assessment	As stated in the Joint Programme Regulations. http://www.engineering.aau.dk/uddannelse/studieadministration/

FACTS ABOUT THE MODULE

Danish title	Fejlfinding og diagnosticeringsteknikker
Module code	N-IRS-K2-3
Module type	Course
Duration	1 semester

Semester	Spring
ECTS	5
Empty-place Scheme	Yes
Location of the lecture	Campus Esbjerg
Responsible for the module	Zhenyu Yang

ORGANISATION

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

RELIABILITY MODELING AND ANALYSIS

2018/2019

PREREQUISITE/RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

Probability, statistics and stochastic processes

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

Purpose

The course purpose consists of two parts:

- To contribute to students' attainment of comprehension of fundamental principles for reliability modelling
- To contribute to students' attainment of comprehension of fundamental principles for reliability analysis

Content

- Principles of reliability modelling
  - Quality and reliability
  - Creating reliability vs. measuring reliability
  - Failure modes, causes and mechanisms
- Probabilistic models of failure phenomena
  - Essentials of probability theory
  - Probabilistic definition of reliability
- Component reliability
  - Common distribution in component reliability
  - Component reliability model selection
- System reliability analysis
  - Structure analysis and design
  - Reliability block diagram method
  - Fault modes and effects analysis
  - Fault tree analysis
- Hazard and risk analysis
- Reliability analysis of dynamic systems
  - Markov theory and applications
  - Simulation methods (Monte Carlo methods)
  - Analysis of fault tolerant systems
- Bayesian analysis
  - Foundations of Bayesian statistical inference
  - Bayesian inference in reliability
  - Performing Bayesian reliability analysis
  - Bayesian decision and estimation theory
- Uncertainty analysis and propagation methods
  - Measuring uncertainty
  - Uncertainty propagation
- Reliability in computer systems
  - Hardware reliability vs. software reliability
  - Software reliability improvement methods
  - Software reliability assessment methods

LEARNING OBJECTIVES

KNOWLEDGE

- Have comprehension of fundamental principles for reliability modelling and analysis
- Have comprehension of reliability analysis using logic diagrams
- Have comprehension of Bayesian methods for simple reliability modelling and analysis

SKILLS

- Be able to apply probabilistic methods for reliability modelling and analysis.
- Be able to judge the usefulness of the set up methods
- Be able to relate the methods to applications in the industry

COMPETENCES

- Independently be able to define and analyze scientific problems within the area of reliability modelling and analysis.
- Independently be able to be a part of professional and interdisciplinary development work within the area of reliability modelling and analysis.

TYPE OF INSTRUCTION

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

- Lectures
- Classroom instruction
- Project work
- Workshops
- Exercises (individually and in groups)
- Teacher feedback
- Reflection
- Portfolio work

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 Modeling and Analysis
Type of exam	Written or oral exam
ECTS	5
Assessment	7-point grading scale
Type of grading	Internal examination
Criteria of assessment	As stated in the Joint Programme Regulations. http://www.engineering.aau.dk/uddannelse/studieadministration/

FACTS ABOUT THE MODULE

Danish title	Pålidelighedsmodellering og analyse
Module code	N-IRS-K2-4
Module type	Course
Duration	1 semester
Semester	Spring
ECTS	5
Empty-place Scheme	Yes
Location of the lecture	Campus Esbjerg

Responsible for the module	Zhenyu Yang

ORGANISATION

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

ADVANCED CONTROL AND ESTIMATION

2018/2019

PREREQUISITE/RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

2nd semester at the Master of Science in Intelligent Reliable Systems or alike.

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

Purpose
The purpose of the project unit is to contribute to students' attainment of knowledge about advanced control and estimation technologies and their engineering applications

Content
The project is based on a design problem for advanced control and/or estimation system. The considered physical system can be a (petro-) chemical process, mechanical system, or any other safety-critical systems. The control and/or estimation design should take advanced technology into consideration instead of employing fundamental control and/or estimation solution. The strategies and methods for this design are encouraged to consider using some intelligent approaches as support tools. The chosen solution has to be implemented on a real-time platform and tested, either by the computer simulations or a dedicated hardware system. The students in the project work shall demonstrate their ability to handle complex problems by scientific methods.

LEARNING OBJECTIVES

KNOWLEDGE

- Have the knowledge and comprehension of fundamental principles, characteristics and limitations of some advanced control and estimation techniques, such as model-based adaptive control, optimal control, model predictive control as well as model -based/-free intelligent control.
- Have knowledge and comprehension of different advanced control methods and their potential applications in engineering systems.

SKILLS

- Be able to judge the usefulness of the selected different scientific methods for the design of advanced control and estimation for engineering systems.
- Be able to analyze, realize and test the selected control and estimation method in a professional manner

COMPETENCES

- Be able to control the working and development process within the project theme, and be able to develop new solutions within advanced control and estimation of engineering systems.
- Be able to show entrepreneurship to define and analyse scientific problems in the area of advanced control and estimation of engineering systems, and based on that make and state the reasons for decisions made.
- Be able to set up innovative ideas within the area of advanced control and estimation of engineering systems
- Independently be able to continue own development in competences and specialization

TYPE OF INSTRUCTION

Project work.

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

EXAMS

Name of exam	Advanced Control and Estimation
Type of exam	Oral exam based on a project
ECTS	20
Assessment	7-point grading scale
Type of grading	Internal examination
Criteria of assessment	As stated in the Joint Programme Regulations. http://www.engineering.aau.dk/uddannelse/studieadministration/

ADDITIONAL INFORMATION

Elective project
On this semester one project must be chosen out of two elective projects (total: 20 ECTS).

FACTS ABOUT THE MODULE

Danish title	Avanceret kontrol og estimering teknologi
Module code	N-IRS-K3-1
Module type	Project
Duration	1 semester
Semester	Autumn
ECTS	20
Empty-place Scheme	Yes
Location of the lecture	Campus Esbjerg
Responsible for the module	Zhenyu Yang

ORGANISATION

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

DESIGN OF INTELLIGENT RELIABLE SYSTEMS

2018/2019

PREREQUISITE/RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

2nd semester at the Master of Science in Intelligent Reliable Systems or alike.

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

Purpose
The purpose of the project unit is to contribute to students' attainment of knowledge about how to design intelligent control-, diagnostic- or surveillance systems with the consideration of reliability.

Content
The project is based on a design problem for reliable control system. The considered physical system can be a (petro-) chemical process, mechanical system, or any other safety-critical systems. The control system design should take fault tolerant control into consideration. The strategies and methods for fault tolerant deign is determined for the considered system possibly using some intelligent approaches as support tools. The chosen solution has to be implemented on a real-time platform and tested, either by the computer simulations or a dedicated hardware system. The students in the project work shall demonstrate their ability to handle complex problems by scientific methods.

LEARNING OBJECTIVES

KNOWLEDGE

- Have knowledge and comprehension for how to design control-, diagnostic- and surveillance systems by taking the reliability into consideration.
- Have knowledge and comprehension of different advanced control methods and their potential application in intelligent reliable system development.

SKILLS

- Be able to judge the usefulness of the used different scientific methods for the design of intelligent control-, diagnostic- and surveillance systems for engineering systems.
- Be able to apply quantitative and qualitative, intelligent and/or model-based methods for reliable system design

COMPETENCES

- Be able to control the working and development process within the project theme, and be able to develop new solutions within intelligent control-, diagnostic- and surveillance of engineering systems.
- Be able to show entrepreneurship to define and analyze scientific problems in the area of control-, diagnostic- and surveillance of engineering systems, and based on that make and state the reasons for decisions made.
- Be able to set up innovative ideas within the area of control-, diagnostic- and surveillance of engineering systems
- Independently be able to continue own development in competences and specialization

TYPE OF INSTRUCTION

Project work.

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

EXAMS

Name of exam	Design of Intelligent Reliable Systems
Type of exam	Oral exam based on a project
ECTS	20
Assessment	7-point grading scale
Type of grading	Internal examination
Criteria of assessment	As stated in the Joint Programme Regulations. http://www.engineering.aau.dk/uddannelse/studieadministration/

ADDITIONAL INFORMATION

Elective project
On this semester one project must be chosen out of two elective projects (total: 20 ECTS).

FACTS ABOUT THE MODULE

Danish title	Design af intelligente pålidelige systemer
Module code	N-IRS-K3-2
Module type	Project
Duration	1 semester
Semester	Autumn
ECTS	20
Empty-place Scheme	Yes
Location of the lecture	Campus Esbjerg
Responsible for the module	Zhenyu Yang

ORGANISATION

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

MACHINE LEARNING

2018/2019

PREREQUISITE/RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

Basic knowledge in probability theory, statistics, and linear algebra.

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

Objective
The course gives a comprehensive introduction to machine learning, which is a field concerned with learning from examples and has roots in computer science, statistics and pattern recognition. The objective is realized by presenting methods and tools proven valuable and by addressing specific application problems.

LEARNING OBJECTIVES

KNOWLEDGE

- Must have knowledge about supervised learning methods including K-nearest neighbor’s, decision trees, linear discriminant analysis, support vector machines and neural networks
- Must have knowledge about unsupervised learning methods including: K-means, Gaussian mixture model, hidden Markov model, EM algorithm, and principal component analysis
- Must have knowledge about probabilistic graphical models, variational Bayesian methods, belief propagation, and mean-field approximation
- Must have knowledge about Bayesian decision theory, bias and variance trade-off, and cross-validation.
- Must be able to understand reinforcement learning

SKILLS

- Must be able to apply the taught methods to solve concrete engineering problems
- Must be able to evaluate and compare the methods within a specific application problem

COMPETENCES

- Must have competencies in analyzing a given problem and identifying appropriate machine learning methods to the problem
- Must have competencies in understanding the strengths and weaknesses of the methods

TYPE OF INSTRUCTION

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

- Lectures
- Classroom instruction
- Project work
- Workshops
- Exercises (individually and in groups)
- Teacher feedback
- Reflection
- Portfolio work

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	Machine Learning
Type of exam	Written or oral exam
ECTS	5
Assessment	Passed/Not Passed
Type of grading	Internal examination
Criteria of assessment	As stated in the Joint Programme Regulations. http://www.engineering.aau.dk/uddannelse/studieadministration/

ADDITIONAL INFORMATION

Elective course
On this semester two courses must be chosen out of three elective courses (total: 10 ECTS).

FACTS ABOUT THE MODULE

Danish title	Maskinlæring
Module code	N-IRS-K3-3
Module type	Course
Duration	1 semester
Semester	Autumn
ECTS	5
Empty-place Scheme	Yes
Location of the lecture	Campus Esbjerg
Responsible for the module	Birgitte Bak-Jensen

ORGANISATION

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

INTELLIGENT CONTROL AND RELIABILITY ORIENTED DESIGN

2018/2019

PREREQUISITE/RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

Linear control theory, numerical methods, optimization theory

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

Purpose

The course purpose is to contribute to students' attainment of knowledge about some typical intelligent control methods with consideration of reliability

Content

- Intelligent control based on fuzzy logic and neural networks
    - Boolean logic, fuzzy theory of sets, membership functions, fuzzy logic
    - Fuzzy relations, fuzzy rule bases, defuzzication
    - Fuzzy modelling and fuzzy control
    - Neuron model, learning, back propagation error, gradient methods,
    - The coherence between regression and defuzzification, neural-fuzzy systems, learning in rule bases, extraction of rules from neural network

- Supervisory control
    - Discrete event systems and models
    - Languages and automata
    - Safety, blocking, state estimation and diagnosis
    - Controllability theorem
    - Supervisory control problem and their solutions

- Hybrid control systems
    - Terminology of hybrid systems
    - Control architectures of hybrid systems
    - Modelling of hybrid systems, Hybrid automaton and its operation
    - Reachability and controllability analysis
    - Stability of hybrid systems
    - Multiple Lyapunov function method
    - Control synthesis for linear switched hybrid systems

- Active fault-tolerant (reconfigurable) control
    - General structure of active FTCS
    - Classification of existing design strategies
    - Incorporation of performance degradation in designing FTCS
    - Reliability assessment of FTCS
    - Reconfigurable controller design techniques
- Statistic estimation of reliability
- Reliability evaluation of FDD methods

LEARNING OBJECTIVES

KNOWLEDGE

- Have comprehension of the fundamental principles of typical intelligent control methods
- Have comprehension of the fundamental principles of reliability oriented design

SKILLS

- Be able to apply different intelligent control algorithms for different engineering problems
- Be able to apply reliability oriented design to solve some specific reliable control problems under the assistance of available computation software

COMPETENCES

- Independently be able to define and analyze scientific problems within the area of intelligent and reliable control
- Independently be able to be a part of professional and interdisciplinary development work within the area of intelligent and reliable control.

TYPE OF INSTRUCTION

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

- Lectures
- Classroom instruction
- Project work
- Workshops
- Exercises (individually and in groups)
- Teacher feedback
- Reflection
- Portfolio work

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	Intelligent Control and Reliability Oriented Design
Type of exam	Written or oral exam
ECTS	5
Assessment	7-point grading scale
Type of grading	Internal examination
Criteria of assessment	As stated in the Joint Programme Regulations. http://www.engineering.aau.dk/uddannelse/studieadministration/

ADDITIONAL INFORMATION

Elective course
On this semester two courses must be chosen out of three elective courses (total: 10 ECTS).

FACTS ABOUT THE MODULE

Danish title	Intelligent regulering og design af pålidelige systemer
Module code	N-IRS-K3-4
Module type	Course
Duration	1 semester

Semester	Autumn
ECTS	5
Empty-place Scheme	Yes
Location of the lecture	Campus Esbjerg
Responsible for the module	Birgitte Bak-Jensen

ORGANISATION

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

ADAPTIVE AND OPTIMAL CONTROL

2018/2019

PREREQUISITE/RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

Linear control theory, numerical methods, optimization theory

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

Purpose
The course purpose is to contribute to students' attainment of knowledge and comprehension of the fundamental knowledge of advanced control with adaptive mechanisms and optimal control techniques.

Content
Adaptive control:

- Introduction to adaptive control
- Typical adaptive control principles and methods
  - Feed-forward adaptive control and feedback adaptive control
- Feedback adaptive control
  - Gain scheduling
  - Model Reference Adaptive Control (MRAC)
    - Gradient optimization MRAC's
    - Stability optimized MRAC's
  - Model identification adaptive control
  - Parametric adaptive control
    - Explicit parameter adaptive control
    - Implicit parameter adaptive control
  - Multiple model adaptive control
  - Self-tuning regulators

Optimal Control:

- Review of optimal control principles
- Infinite horizon optimization: Linear Quadratic (LQ) control
  - Standard problem formulation
  - Solutions and Riccati equations
  - Discrete-time LQ control
  - Linear quadratic Gaussian (LQG)control
  - Application examples
- Finite horizon optimization (I): Minimum Variance Control (MVC)
  - Problem formulation for SISO systems
  - Solution and its properties
  - Generalized MVC
  - Offset problem
  - Self-tuning MVC
- Finite horizon optimization (II): Model predictive Control (MPC)
  - Principles of MPC
  - Typical MPC schemes based on different models
  - Numerical computation algorithms
  - Nonlinear MPC
  - Commercial software and examples
- Adaptive MPC
  - Principles of adaptive MPC
  - Typical algorithms

LEARNING OBJECTIVES

KNOWLEDGE

- Have comprehension of the fundamental principles of typical adaptive control methods
- Have comprehension of the fundamental principles of typical optimal control methods

SKILLS

- Be able to use different adaptive and optimal control algorithms.
- Be able to apply some typical adaptive/optimal control methods to solve some specific linear control problems under the assistance of available computation software

COMPETENCES

- Independently be able to define and analyze scientific problems within the area of adaptive and optimal control.
- Independently be able to be a part of professional and interdisciplinary development work within the area of adaptive and optimal control.

TYPE OF INSTRUCTION

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

- Lectures
- Classroom instruction
- Project work
- Workshops
- Exercises (individually and in groups)
- Teacher feedback
- Reflection
- Portfolio work

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 Optimal Control
Type of exam	Written or oral exam
ECTS	5
Assessment	7-point grading scale
Type of grading	Internal examination
Criteria of assessment	As stated in the Joint Programme Regulations. http://www.engineering.aau.dk/uddannelse/studieadministration/

ADDITIONAL INFORMATION

Elective course
On this semester two courses must be chosen out of three elective courses (total: 10 ECTS).

FACTS ABOUT THE MODULE

Danish title	Adaptiv og optimal regulering
Module code	N-IRS-K3-5
Module type	Course
Duration	1 semester
Semester	Autumn
ECTS	5
Empty-place Scheme	Yes
Location of the lecture	Campus Esbjerg
Responsible for the module	Birgitte Bak-Jensen

ORGANISATION

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

MASTER'S THESIS

2018/2019

PREREQUISITE/RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

3rd semester at the Master of Science in Intelligent Reliable Systems or alike.

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

Purpose

The purpose of the project unit is to contribute to students' documentation of his/her obtained skills and the level at which he/she is able to exploit these skills in solving a specified task within the specialization of Intelligent Reliable Systems.

Content

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 Intelligent Reliable Systems. 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 Intelligent Reliable Systems technology.

LEARNING OBJECTIVES

KNOWLEDGE

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

SKILLS

- Be able to judge the usefulness of different scientific methods and tools for analysis and problem solving within the field of Intelligent Reliable Systems
- Be able to use advanced laboratory set ups, data analysis methods and analysis and modelling methods within the field of Intelligent Reliable Systems.
- Be able to communicate about scientific problems both to specialist and the public.
- Have obtained skills related to the industrial area within Intelligent Reliable Systems technology

COMPETENCES

- Be able to control complex/unexpected working and development situations within the Intelligent Reliable Systems area, and be able to develop new solutions.
- Independently be able to define and analyze scientific problems, and based on that make and state the reasons for decisions made.
- Independently be able to continue own development in competences and specialization
- Independently be able to be the head of professional and interdisciplinary development work and be able to undertake the professional responsibility.

TYPE OF INSTRUCTION

Project work.

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	Oral exam based on a project
ECTS	30
Assessment	7-point grading scale
Type of grading	External examination
Criteria of assessment	As stated in the Joint Programme Regulations. http://www.engineering.aau.dk/uddannelse/studieadministration/

FACTS ABOUT THE MODULE

Danish title	Kandidatspeciale
Module code	N-IRS-K4
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	Zhenyu Yang
Time allocation for external examiners	D

ORGANISATION

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

MASTER'S THESIS

2018/2019

PREREQUISITE/RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

Previous semesters at the Master of Science in Intelligent Reliable Systems or alike

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

Purpose
The purpose of the project unit is to contribute to students' documentation of his/her obtained skills and the level at which he/she is able to exploit these skills in solving a specified task within the specialization of Intelligent Reliable Systems.

Content
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 Intelligent Reliable Systems. The project must be of experimental nature, and will often be in collaboration with an industrial company or other research institution performing research in the area of Intelligent Reliable Systems technology.

LEARNING OBJECTIVES

KNOWLEDGE

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

SKILLS

- Be able to judge the usefulness of different scientific methods and tools for analysis and problem solving within the field of Intelligent Reliable Systems
- Be able to use advanced laboratory set ups, data analysis methods and analysis and modelling methods within the field of Intelligent Reliable Systems.
- Be able to communicate about scientific problems both to specialist and the public.
- Have obtained skills related to the industrial area within Intelligent Reliable Systems technology

COMPETENCES

- Be able to control complex/unexpected working and development situations within the Intelligent Reliable Systems area, and be able to develop new solutions.
- Independently be able to define and analyze scientific problems, and based on that make and state the reasons for decisions made.
- Independently be able to continue own development in competences and specialization
- Independently be able to be the head of professional and interdisciplinary development work and be able to undertake the professional responsibility.

TYPE OF INSTRUCTION

Project work.

EXTENT AND EXPECTED WORKLOAD

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

EXAM

EXAMS

Name of exam	Master's Thesis
Type of exam	Oral exam based on a project
ECTS	50
Assessment	7-point grading scale
Type of grading	External examination
Criteria of assessment	As stated in the Joint Programme Regulations. http://www.engineering.aau.dk/uddannelse/studieadministration/

ADDITIONAL INFORMATION

As this is a 50 ECTS long Master's Thesis, the learning objectives for the thesis include both the learning objectives for the projects on 3rd and 4th semester.

FACTS ABOUT THE MODULE

Danish title	Kandidatspeciale
Module code	N-IRS-K4LONG
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	Zhenyu Yang
Time allocation for external examiners	D

ORGANISATION

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