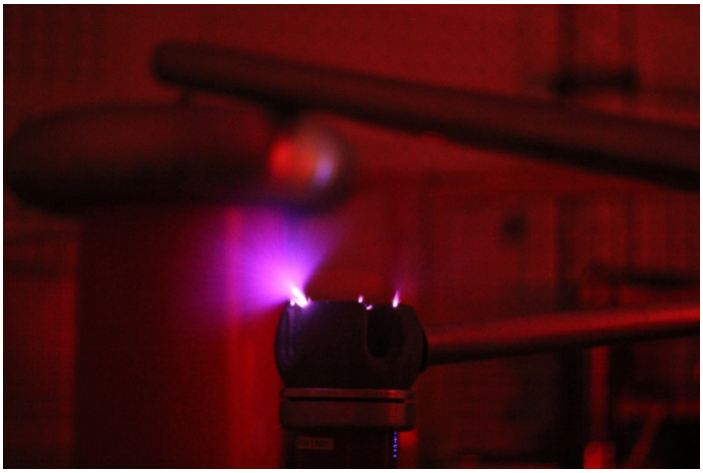
PhD Courses in 2017 at the Department of Energy Technology

Aalborg University

Doctoral School of Engineering and Science

Energy Technology PhD Program



Description of Energy Technology PhD program

The Energy Technology program is a multi-disciplinary doctoral program aiming at solving future challenges in the energy area by means of developing new energy technologies leading to a more efficient and sustainable management of energy. It covers a broad range of energy-related topics focusing on the energy conversion process itself as well as generation, transmission, distribution and efficient use of energy are covered. Inherently it is involving various areas of both classical and new engineering sciences as well as basic research as the physical quantity “energy” and it’s provision and use spans broadly over almost all activities a modern society faces. Electrical, thermal, mechanical, hydraulics and control engineering sciences merge in various ratios with physics and chemistry to provide front-end knowledge enabling step by step solutions to help fulfilling the climate and emission goals set by international societies. The program is highly experimentally oriented and offers state of the art laboratory facilities. Research cooperation with both Danish and international industries is strong as well as with world class academia.

The program enrolls more than 25 new PhD’s each year and has hosted + 100 PhD’s every year for the last several years and is graduating around 25 new energy technology PhD’s every year.

Research areas:

The program belongs to The Doctoral School of Engineering and Science and focuses on:

- Power Electronics (PE) and its applications with special focus on reliability in PE. Another main focus is the interaction of PE with power systems and generation and load units.
- Electrical Power Systems including production, transmission, distribution of electrical energy as well as power quality, stability, control and protection in AC and DC systems.
- High Voltage Engineering with focus on environmentally friendly overhead lines
- Smart grid and micro grid and their application to modern societies
- Energy Efficiency as a universal term spanning the above science areas
- Renewable energy generation technologies incl. wind turbines and offshore wind power plants, photovoltaic, wave energy, thermoelectric, fuel cells and biofuels.
- Reliability, diagnosis and predictive maintenance of electrical and thermal components and systems
- Energy harvesting systems such as thermo-electric generators and systems
- Automotive and industrial drives including the design of electrical motors and generators and gears in combination with their power electronics and control.
- Systems analysis, design and optimization of a wide range of energy processes, machines and systems
- Heating/cooling systems and their distribution networks (domestic heating)
- Biomass to energy systems, including biomass to liquid fuels and end use applications
- Fluid power systems and their control
- Energy storage and power management
- Analysis and optimization of thermal cycles.

Head of Doctoral Program, Professor Claus Leth Bak - clb@et.aau.dk, 99409281

Link: http://www.et.aau.dk/phd/phd-courses/

Registration: https://phd.moodle.aau.dk/

Courses - 2017	ECTS	Start	End	Organizer
Introduction to Wind Power (Generation and Integration)	4	06-02-2017	09-02-2017	Zhe Chen
Renewable Energy based Integrated Energy Systems	3	13-02-2017	15-02-2017	Zhe Chen
Electricity Market and Power System Optimization	3	20-02-2017	22-02-2017	Zhe Chen
Advanced Topics in Pulse Width Modulation for Voltage Source Converters	2	06-03-2017	07-03-2017	Laszlo Mathe
Preparation of research plan for PhD's - Spring	1	10-03-2017	10-03-2017	Frede Blaabjerg
Active Fault-Tolerant Control: Theory and Applications	4	20-03-2017	24-03-2017	Zhenyu Yang
Resources and technology pathways for Advanced Biofuels	5	27-03-2017	31-03-2017	Jens Bo Holm-Nielsen
Underground and Submarine Power Cables	3	05-04-2017	07-04-2017	Filipe Faria da Silva
Advanced FPGA- Based Controllers for Power Electronic and Drive Applications	2	19-04-2017	20-04-2017	Josep M. Guerrero
AC Microgrids	2	24-04-2017	25-04-2017	Juan C. Vasquez
Power Quality in Microgrids	3	26-04-2017	28-04-2017	Josep M. Guerrero
DC Microgrids	2	01-05-2017	02-05-2017	Juan C. Vasquez
Optimization Strategies and Energy Management Systems	3	03-05-2017	05-05-2017	Juan C. Vasquez
Application-Oriented Modelling of Renewable Energy Sources, Conversion and Energy Storage Systems	4	08-05-2017	11-05-2017	Sergiu Spataru
Stability and Control of Grid-Connected Voltage-Source Converters	3	15-05-2017	17-05-2017	Xiongfei Wang
Understand how to write good papers for high level journals	1,5	22-05-2017	23-05-2017	Kaiyuan Lu
Power System Stability and Control – with focus on offshore wind power plants	4	06-06-2017	09-06-2017	Claus Leth Bak
Advanced Computational Fluid Dynamics	4	21-08-2017	24-08-2017	Chungen Yin
Electrochemical Energy Conversion	4	28-08-2017	31-08-2017	Torsten Berning
Smart Distribution Systems	3	12-09-2017	15-09-2017	Birgitte Bak-Jensen
Stability of Modern Power Systems with High Penetration of Renewable Energy	3	18-09-2017	20-09-2017	Sanjay K Chaudhary
Electromagnetic Transients in Power Systems	3	27-09-2017	29-09-2017	Filipe Faria da Silva
An Introduction to HVDC and MTDC Transmission System	3	02-10-2017	04-10-2017	Sanjay K Chaudhary
Preparation of research plan for PhD's - Fall	1	06-10-2017	06-10-2017	Frede Blaabjerg
Reliability in Power Electronics Systems	3	11-10-2017	13-10-2017	Frede Blaabjerg
Photovoltaic Power Systems - in theory and practice	4	17-10-2017	20-10-2017	Dezso Sera
Storage Systems based on Li-ion Batteries for Grid Support and Automotive Applications	4	24-10-2017	27-10-2017	Remus Teodorescu
Modern Power Semiconductors and their Packaging	3	31-10-2017	03-11-2017	Francesco Iannuzzo
Reluctance electric motor drives for high efficiency in line start and variable speed applications	2,5	07-11-2017	08-11-2017	Frede Blaabjerg
Encoderless control of electric drives motors and generators	3	09-11-2017	10-11-2017	Frede Blaabjerg
Modeling and optimization of thermal systems	2	13-11-2017	15-11-2017	Mads Pagh Nielsen
Harmonics in Power Electronics and Power Systems	3	20-11-2017	22-11-2017	Claus Leth Bak
Capacitors in Power Electronics Applications	2	23-11-2017	24-11-2017	Huai Wang
Modular Multilevel Converters MMC	4	28-11-2017	01-12-2017	Remus Teodorescu

AC Microgrids

Organizers: Associate Professor Juan C. Vasquez, juq@et.aau.dk, Aalborg University

Professor Josep M. Guerrero, joz@et.aau.dk, Aalborg University

Lecturers: Professor Josep M. Guerrero, Aalborg University, Associate Professor Juan C. Vasquez, Aalborg University , Professor Ernane Coelho, Universidade Federal de Uberlândia – Brazil, Postdoc Yajuan Guan, Aalborg University.

ECTS: 2

Date: 24 – 25 April 2017

Max no. of participants: 20

Description:

A Microgrid can be defined as a part of the grid with elements of prime energy movers, power electronics converters, distributed energy storage systems and local loads, that can operate autonomously but also interacting with main grid. The functionalities expected for these small grids are: black start operation, frequency and voltage stability, active and reactive power flow control, active power filter capabilities, and storage energy management. This way, the energy can be generated and stored near the consumption points, increasing the reliability and reducing the losses produced by the large power lines.

The course starts giving some examples of Microgrids in the world. The course participants not only will learn modeling, simulation and control of three-phase voltage source inverters operating in grid-connected mode and islanded mode, but also, how these power electronics converters are integrated in AC Microgrids.
Relevant concepts like frequency and voltage droop control as well as the virtual impedance concept are explained in detail. Finally, this course also introduces the study of the hierarchical control of Microgrids for AC electrical distribution systems.

Prerequisites:

Matlab/Simulink knowledge is recommended for the exercises.

Active Fault-Tolerant Control: Theory and Applications

Organizer:	Associate Professor Zhenyu Yang, yang@et.aau.dk, Aalborg University
Lecturers:	Associate Professor Zhenyu Yang, Aalborg University, Dr. Jie Chen, Brunel University, UK
ECTS:	4
Date:	20 - 24 March 2017
Place:	Aalborg University, Esbjerg Campus, Niels Bohrs Vej 8, 6700 Esbjerg

Max. no. of participants: 30

Description: A Fault-Tolerant Control (FTC) system is referred to a controlled system that poses the capability to accommodate system component faults/failures automatically and is capable of maintaining overall system stability and acceptable performance in the event of such faults. In general, the FTC capability can be possibly achieved through *passive* or *active* approaches. The passive FTC is limited by the nominal control system's robustness, while the active FTC approach often consists of two integrated online functionalities, i.e., Fault Detection and Diagnosis (FDD) and Control Reconfiguration (CR). Thereby, the active FTC is also regarded as a kind of intelligent control solution.

The FTC plays an essential rule in safe-critical systems, which now cover a wide range of engineering systems, from aircrafts, airspace systems and nuclear reactors, to the recent emerging energy systems, such as smart grid systems, offshore wind farms etc. The ultimate objective of applying FTC techniques is to cost-effectively increase engineering system's reliability, safety availability and maintainability.

The course covers the fundamental essentials and some latest results in FTC research area, along with diverse application case studies. The main content consists of: Historical and technical overview & terminology; FDD techniques (data-driven & model-based); CR techniques (model-matching & model-following): Integration of FDD and CR: fundamental FDD/FTC property analysis and diverse case studies.

The course will be evaluated based on a mini-project after the course. This mini-project expects some illustration that the student can apply some techniques/knowledge learned from this course into their current PhD project.

Literatures:

Lecture notes/slides will be provided and the following two books are recommended:

- Jie Chen and R. Patton, "Robust model-based fault diagnosis for dynamic systems", Kluwer, Boston, 1999.
- R. Isermann, "Fault-diagnosis systems: An introduction from fault detection to fault tolerant", Springer, 2006. ISBN 3-540-24112-4.

Prerequisites:
Basic knowledge of control theory (incl. state-space methods)

Advanced Computational Fluid Dynamics

Organizer: Associate Professor Chungen Yin, chy@et.aau.dk, Aalborg University

Lecturers: Associate Professor Chungen Yin, Aalborg University
Associate Professor Anders Christian Olesen, Aalborg University
Associate Professor Torsten Berning, Aalborg University

ECTS: 4

Date: 21 – 24 August 2017

Max. no. of participants: 25

Description: This PhD course is an introduction to advanced computational fluid dynamics (CFD) and its numerous applications. It will provide

- a familiarity with the finite volume method which is the core of CFD, including spatial and temporal discretization schemes, pressure-velocity coupling, boundary conditions, and so on;
- a familiarity with turbulent flows and their modeling, which covers Reynolds Averaged Navier-Stokes simulations (e.g., k-ε, k-ω) & scale-resolving simulations (e.g., large eddy simulation);
- a familiarity with multiphase flows and flows through porous media and their modeling, e.g., Lagrangian method, volume of fluid approach, mixture and Eulerian approach;
- a familiarity with combustion flows and their modelling, e.g., species transport/eddy dissipation (or eddy dissipation concept), and mixture fraction/PDF;
- a familiarity of development of customized physical models into commercial CFD codes via User Defined Functions (UDF);
- some demos/hands-on, e.g., solving simple problems by programming, solving complicated engineering problems using commercial CFD, developing UDFs into commercial CFD, etc.

As the conclusion of the course, an attendee will be well prepared to understand and follow more sophisticated state-of-the-art literature in this field, to be able to develop his or her own CFD codes using FVM to solve simple problems, and to begin advanced applications of CFD to his or her areas of concern. This PhD course is aimed at recent graduates, professional engineers and the likes.

Prerequisites: Basic knowledge in fluid flow, turbulence, multiphase flow, combustion & programming

Literature: Versteeg, H.K.; Malalasekera, W. An introduction to computational fluid dynamics – The finite volume method (2nd edition). Pearson Education Limited, 2007 (ISBN 978-0-13-127498-3)

Advanced FPGA-based Controllers for

Power Electronic and Drive Applications

Organizer: Professor Josep M. Guerrero, joz@et.aau.dk, Aalborg University,

Associate Professor Juan C. Vasquez, juq@et.aau.dk, Aalborg University

Lecturers: Professor Eric Monmasson, University of Cergy-Pontoise, France, Assistant Professor Lahoucine Idkajine, University of Cergy-Pontoise

ECTS: 2

Date: 19 – 20 April 2017

Max no. of participants: 20

Description: Digital controllers are now extremely powerful. With the current Field Programmable Gate Array (FPGA), designing a controller is no longer limited to the programming of a microprocessor but includes also the programming of the architecture of the processor itself along with its peripherals and its computing accelerators. As a consequence, the control designer should be now a system architect who also needs a deep understanding of the final system to be controlled. Along this line, this course aims to propose a rational use of current FPGA reconfigurable platforms for controlling power electronic and drive applications.

The following topics are covered in the course:

- Introduction, presentation of the current trends in terms of digital control implementation for electrical systems.
- Description of FPGA components (Internal architecture of FPGAs, recent System-on-Chip extension, presentation of the corresponding development tools)
- Main design rules of an FPGA-based controller: Control algorithm refinement (design of a time continuous controller, internal delay issues, digital re-design, sampling issues, quantization issues). Architecture refinement (algorithm architecture matching, IP-modules reusability, Hardware-In-the-Loop (HIL) validation, system-on-chip extension)
- Presentation of practical cases: Current control of a synchronous motor drive, sensorless control techniques (Kalman filtering, high frequency injection).
- Hands-on the FPGA-based control of a three phase inverter connected to the grid (PI current controller, PR current controller, sliding mode current controller, predictive current controller)

Prerequisites: Matlab/Simulink knowledge is recommended for the exercises.

Advanced Topics in Pulse Width Modulation for Voltage Source Converters

Organizer:	Associate Professor Laszlo Mathe, lam@et.aau.dk, Aalborg University
Lecturers:	Professor Stig Munk-Nielsen, Aalborg University, Associate Professor Laszlo Mathe, Aalborg University, Associate Professor Sanjay Kumar Chaudhary, Aalborg University
ECTS:	2
Date:	6 - 7 March 2017
Max. no. of participants:	30

Description:

These days the electric energy conversion is mainly based on single and three-phase voltage source converters (VSC), starting from low up to high power. Different topologies are used for VSCs depending on their application, such as: power rating, voltage/current rating, employed semiconductor devices etc. The pulse width modulation (PWM) methods are the key techniques to control such VSCs.

The objective of the course is to present the PWM techniques, starting from the theoretical aspects to the practical issues. Thus, the course starts with a brief presentation of the classical PWM schemes, which is followed by a hands-on experience in simulations and dSpace controlling electrical drives. A new trend is to use highly integrated converters by employing wide bandgap devices, where soft switching is applied. Several soft switching techniques and design aspects are presented, followed by reliability issues of the power devices.

The morning session of the second day starts with presentation of the state of art semiconductor devices used in medium power converters and their limitations related to the modulation schemes. The afternoon session focuses on used in high voltage converters (typically used in energy transport). Due to their high efficiency, scalability, high reliability the Modular Multilevel Converters (MMC) are in the focus of the researchers. Different topologies, modulation and control techniques for MMC are presented, while the testing of the presented methods are done by using simulation models.

Course Programme:

Day 1, 08.30-17.00	Day 2, 08.30-17.00
08:30-08:45: Registration & Welcome; 08:30-10:00: Basics of PWM for 2 level topologies 10:30-12:00: Simulation models for different PWM schemes 13:00-13:45: Soft switching techniques for highly integrated converters 13:45-14:30: Effects of the modulation on the power switches 15:00-16:30: Laboratory exercise: Implementation of the modulation schemes in dSpace environment 16:30-17:00: Discussion	08:30-10:00: Medium power converters 10:30-12:00: Laboratory exercises 13:00-13:45: MMC – Topologies 13:45-14:30: MMC – Modulation and control 15:00-16:30: Simulation techniques for MMC using Matlab/Simulink and/or Plecs 16:30-17:00: Discussion

An Introduction to HVDC and MTDC Transmission System

Organizer: Associate Professor Sanjay K Chaudhary, skc@et.aau.dk, Aalborg University

Lecturers: Associate Professor Sanjay K Chaudhary, skc@et.aau.dk, Aalborg University

Professor Remus Teodorescu ret@et.aau.dk, Aalborg University

ECTS: 3

Time: 2 - 4 October 2017

Max. no. of participants: 30

Description:

This course introduces the HVDC transmission in power systems.

Line commutated converter (LCC) based High Voltage DC (HVDC) has been used worldwide for the transmission of bulk power over long distances. Voltage source converter-based HVDC (VSC-HVDC) transmission provides fast control of active and reactive power in all four quadrants. Nowadays, the concepts of multi-terminal dc (MTDC) grids interconnecting multiple energy resources and grids have been proposed.

A detailed description of the LCC-HVDC, VSC-HVDC (both using the two-level converters and the MMC-HVDC) and MTDC and their basic control schemes will be presented. The course will include lectures and simulation exercises. Simulation tools like PSCAD-EMTDC and DigSILENT will be used to demonstrate these applications.

Main topics are:

- Limitations of ac power transmission and the need for HVDC
- Classic HVDC transmission (LCC HVDC): Introduction, operation and control
- VSC-HVDC transmission for the connection of relatively weak grids, and grid connection of renewable energy sources - Introduction, operation and control
- Evolution of Modular multi-level converters (MMC) and MMC-HVDC - Introduction, operation and control
- Multi-terminal DC transmission system

Application-Oriented Modelling of Renewable Energy Sources, Conversion and Energy Storage Systems

Organizer: Postdoc Sergiu Spataru, ssp@et.aau.dk, Aalborg University
Associate Professor Dezso Sera, des@et.aau.dk, Aalborg University

Lecturers: Associate Professor Dezso Sera, Aalborg University
Associate Professor Tamas Kerekes, Aalborg University
Associate Professor Florin Iov, Aalborg University
Assistant Professor Daniel-Ioan Stroe, Aalborg University
Associate Professor Maciej Swierczynski, Aalborg University
Postdoc Sergiu Spataru, Aalborg University

ECTS: 4

Date: 8 – 11 May 2017

Description: This four-day course provides an overview and hands-on experience into the most common modelling methods used for the design, analysis, and planning of solar photovoltaic (PV) generation, wind power (WP) , and energy storage (ES) systems.

The course will focus on the applicability and practical implementation of the models, and cover the following main topics:

i) modelling solar and wind resource: from high frequency variations to hourly, daily, and monthly averaged models;
ii) detailed/dynamic models of the photovoltaic generator (PVG), wind turbine generator (WTG), power electronic converter (PEC) and battery storage system (BSS), used in applications where models with a high bandwidth are required, such as switching converter applications;
iii) averaged, performance, and ageing models of the PVG, WTG, PEC, and BSS used in power system integration studies, power plant design, or performance monitoring and analysis.

The mornings are dedicated to lectures, while the afternoons are spent with off-line application examples and exercises in Matlab/Simulink, and laboratory exercises focusing on Real Time implementation using Opal-RT, where the students will apply the models and methodology in practice. No less than 40% of the course time is spent in the state-of-the-art **Photovoltaic Systems Laboratory** and the **Smart Energy Systems Laboratory** at the Department of Energy Technology at Aalborg University.

Prerequisites: Basic Matlab/Simulink knowledge is recommended for the exercises.

Capacitors in Power Electronics Applications

Organizer: Associate Professor Huai Wang, hwa@et.aau.dk, Aalborg University

Lecturers: Associate Professor Huai Wang, Aalborg University

ECTS: 2

Date: 23-24 November 2017

Max no. of participants: 30

Description:

Capacitors are one of the key components in typical power electronic systems in terms of cost, volume, and reliability. Power electronics applications are consuming unprecedented quantities of electrolytic capacitors, film capacitors, and ceramic capacitors. This industrial/PhD course will discuss the sizing, modeling, and reliability analysis of capacitors from an application perspective, focusing on both classical and emerging power electronics applications. It is the latest research outcome of several PhD projects and industrial collaboration activities. The course will cover the following aspects:

1) Basics of capacitors and its functions in power electronic converters
2) Emerging capacitor technologies and latest developments
3) Capacitor sizing criteria in power electronics by considering steady-state performance, transient and stability performance under both normal and abnormal operations
4) Reliability of electrolytic capacitors, film capacitors, and ceramic capacitors
5) Mission profiled based electro-thermal-lifetime modeling of capacitors
6) Condition monitoring and protection of capacitors in power electronics applications
7) Capacitor minimization techniques in power electronic systems
8) Case studies in DC-DC converters, Modular Multi-level Converters (MMC), photovoltaic inverters, wind power converters, adjustable-speed-drives, Solid-State-Transformers (SST), and ultra-low inductive capacitor bank design.

Prerequisites:
Basic understanding of power electronics circuits and control

DC Microgrids

Organizer: Associate Professor Juan C. Vasquez, juq@et.aau.dk, Aalborg University

Professor Josep M. Guerrero, joz@et.aau.dk, Aalborg University

Lecturers: Associate Professor Juan C. Vasquez, Aalborg University, Professor Josep M. Guerrero, Aalborg University, Associate Professor Sanjay K. Chaudhary, Aalborg University, Postdoc Sun Bo, Aalborg University, PhD Student Enrique Diaz, Aalborg University, Dr. Xiaonan Lu, Energy Systems Division in Argonne National Laboratory - USA

ECTS: 2

Date: 1 – 2 May 2017

Max no. of participants: 20

Description: DC distribution and transmission systems are a clear trend in electrical networks. The focus of this course is on modeling, control and operation of DC Microgrids, starting with stability and control strategies analyzed in detail, DC droop, virtual impedance concepts and hierarchical control structures for DC microgrids are also introduced. Control of DC-DC and AC-DC converters oriented as DC Microgrid interfaces are evaluated.

Distributed energy storage systems and nature DC output generation systems are presented showing their interaction in DC distribution Microgrids. The course also shows examples of DC microgrids in different applications like telecommunication systems or residential DC electrical distribution systems and hybrid AC-DC microgrids.

Prerequisites Matlab/Simulink knowledge is recommended for the exercises.

Electricity Market and Power System Optimization

Organizer: Professor Zhe Chen, zch@et.aau.dk, Aalborg University, Assistant Professor Jiakun Fang, jfa@et.aau.dk, Aalborg University

Lecturers: Professor Andrés Ramos Galán - Institute for Research in Technology - UK

ECTS: 3

Date: 20 - 22 February 2017

Max no. of participants: 30

Description:

This course provides a detailed description of decision-making tools for modern power systems under the market environment, addressing the perspectives transmission expansion planning, unit commitment and economic dispatch. These tools rely on stochastic optimization, complementarity theory and decomposition algorithms.

The topics include

- Introduction to the electricity market organization
- Modeling the competition in electric energy markets
- Stochastic unit commitment to coop with the renewable generations
- Probabilistic midterm transmission expansion planning in liberalized markets
- decomposition and acceleration techniques for large-scale optimization problems

Prerequisites:

- Background in power system optimization.
- Fundamental knowledge in electricity markets.

Electrochemical Energy Conversion

Organizer: Associate Professor Torsten Berning, tbe@et.aau.dk, Aalborg University

Lecturers: Associate Professor Torsten Berning, Aalborg University
Associate Professor Vincenzo Liso, Aalborg University
Associate Professor Anders Olesen, Aalborg University
Associate Professor Samuel Araya, Aalborg University

ECTS: 4

Date: 28 – 31 August 2017

Max. no. of participants: 25

Description:
This PhD course is an introduction to electrochemical energy conversion with a focus on fuel cell technology (gas to power) and electrolyzer technology (power to gas). In detail, it will provide

- An introduction to the thermodynamics of electrochemical energy conversion;
- An overview of the different types of fuel cells and elecytrolyzers and their materials;
- An introduction of the different ways of modeling of electrochemical devices and systems;
- A familiarity with the different experimental methods to test and characterize electrochemical energy converters;

As the conclusion of the course, an attendee will be well prepared to understand and follow more sophisticated state-of-the-art literature in this field, to be able to understand simple (zero-dimensional) models of fuel cell systems using software such as EES and know the benefits and drawbacks of advanced (multi-dimensional) models of the fluid flow in electrochemical devices that employ the methods of computational fluid dynamics. The attendee will also have an overview of the various experimental methods that can be employed to test electrochemical devices. This PhD course is aimed at recent graduates, professional engineers and the likes.

Prerequisites: Basic knowledge in thermodynamics and modeling methods such as Engineering Equation Solver (EES) and/or the methods of computational fluid dynamics (CFD).

Literature:

- R. O'Hayre, S.-W. Cha, W. Colella, F. B. Prinz: Fuel Cell Fundamentals, 3rd ed., Wiley, 2016.
- F. Barbir: PEM Fuel Cells - Theory and Practice, 2nd ed., Elsevier, 2012.
- D. Bessarabov, H. Wang, H. Li, N. Zhao: PEM Electrolysis for Hydrogen Production: Principles and Applications, CRC Press 2015.
- S. Lvov: Introduction to Electrochemical Science and Engineering,CRC Press, 2014

Electromagnetic Transients in Power Systems

Organizer: Associate Professor Filipe Miguel Faria da Silva, fss@et.aau.dk, Aalborg University

Lecturers: Associate Professor Filipe Miguel Faria da Silva, Aalborg University

ECTS: 3

Date: 27 – 29 September 2017

Max no. of participants: 20

Description:
Power systems are constantly subjected to disturbances and switching actions. These actions can go from a normal connection/disconnection of a load or line to the opening of a faulted line after a short circuit or the incidence of lightning strokes, among others. These events are known as electromagnetic transients and have a short duration in the range of microseconds/milliseconds.
Even being short duration phenomena, electromagnetic transients are of fundamental importance, as the system is subjected to high currents, voltages and frequencies during those micro/milliseconds, which may damage the electrical equipment. As a result, extensive investigations are made when installing new high voltage equipment, in order to assure that the equipment is not subjected to high stresses.

The participants in the course will learn how to analyse electromagnetic transients and different transient phenomena will be explored through the use of examples and theoretical explanations. The respective countermeasures will be explained and examples given on how to select them.
The course will also focus in the use of software tools for the simulation of the transients, more specifically EMTDC/PSCAD, which will be introduced and explained during the course. The importance of having a proper modelling of the equipment (e.g., overhead lines, underground cables, transformers, …) in function of the phenomena will be demonstrated and guidelines will be provided on how to choose the minimum modelling requirements for different transient phenomena.
Phenomena that will be studied in the course are:

- Basic RLC transients;
- Energisation and de-energisation of capacitor banks;
- Travelling waves and switching phenomena;
- Particularities of switching HVAC cables (zero-missing, influence of bonding, etc…);
- Energisation of transformers;
- Lightning simulation;
- Fault transients;
- Resonances due to switching;
- Guidelines for network modelling;

Prerequisites: Master Degree in Electrical Power System or similar

Encoderless control of electric drives motors and generators

Organizer:	Professor Frede Blaabjerg, fbl@et.aau.dk, Aalborg University
Lecturers:	Professor Ion Boldea, IEEE Fellow, DL, Romania
ECTS:	3
Time:	9 - 10 November 2017 (ends at 12:00 the 10 November)
Max. no. of participants:	30

Description:

Variable speed drives are now used for almost 50% of all drives, to control motion(energy flow) to save energy and increase productivity in variable output processes in all industries: from info-gadgets , robotics through transport, pumps, ventilators, compressors etc , home appliances and electric generators for renewable energy conversion and control.
Advanced position, speed and torque control that produces high precision and quick response performance requires encoder-precision feedback. In low power(torque) applications ,however, the encoder is more expensive than the motor/actuator and in medium and large power they are mechanically fragile; in all drives the accidental stopping of a drive in a safely critical application means large “production interruption costs” until the faulty encoder is replaced. This is how Encoderless control, with position, speed ,torque and flux state observers came into play; in general applications only encoderless control is used while in servo drives the encoderless control is available at least for redundancy.

Outline

The Intensive Course here presents an Overview of present status and trends in Encoderless control of electric drives as follows:
*V/f and I-f scalar control of ac drives with stabilizing loops for faster torque response, extended speed range and high efficiency with variable load and speed: with sample spectacular results, including regenerative braking experiments
*Encoderless Field Oriented Control(E-FOC) of IMs ,SPMSMs, IPMSMs, PM-RSMs and dc excited SMs: with case studies
*Encoderless direct torque and flux control(E-DTFC) of IMs, IPMSMs,PM-RSMs, dc excited SMs: with case studies
*Encoderless FOC of Induction, Doubly fed induction,doubly fed reluctance(brushless), PM and dc excited synchronous variable speed GENERATORS for wind and hydro ,with case studies
* Encoderless Direct active and reactive power control(DPQC) of variable speed generator drives, with case studies
* Robust control of advanced electric drives by case studies: feedback linearization and super-twisting sliding mode FOC and DTFC of IMs and IPMSMs

Harmonics in Power Electronics and Power Systems

Organizer: Professor Claus Leth Bak, clb@et.aau.dk, Aalborg University.

Lecturers: Lucian Asiminoaei – Danfoss and Lukasz Kocewiak – Dong Energy

ECTS: 3

Time: 20 - 22 November 2017

Max. no. of participants: 30

Description:
A 3-day intensive course "Harmonics in Power Electronics and Power Systems". This important course provides a broad overview of power system harmonic problems, methods of analysing, measuring and effectively mitigating them. Extended simulation tools, among others DIgSILENT PowerFactory, harmonic analysis software Danfoss MCT31, Matlab/Simulink or PSpice will be used to assess and study the harmonic distortion at different points of power networks. The results of simulations will be validated in laboratory using specialized equipment, for instance GPS-synchronized measuring instruments.

Topics covered in the course are:

- Power Quality definitions. Generation mechanism of power system harmonics. Harmonic indices.

- Voltage vs. current distortion. Point of Common Coupling (PCC).

- Sources and effects of harmonic distortion.

- Harmonic measuring instruments and measuring procedures in HV and LV networks.

- Mathematical tools and theories for analysing distorted waveforms. Signal processing.

- Modelling of power system components. Harmonic analysis.

- Harmonic load-flow, frequency scan and time domain simulations.

- Software tools for harmonic analysis.

- Harmonic elimination techniques. Passive and active line filters. Filter design.

Introduction to Wind Power (Generation and Integration)

Organizer: Professor Zhe Chen, zch@et.aau.dk, Aalborg University

Lecturers: Professor Zhe Chen, Aalborg University,
Assistant Professor Chi Su, Aalborg University,
Associate Professor Weihao Hu, Aalborg University,
Assistant Professor Fujin Deng, Aalborg University,
Assistant Professor Jiakun Fang, Aalborg University

ECTS: 4

Date: 6 - 9 February 2017

Max no. of participants: 30

Description:

The course will provide training and education in the field of wind power engineering, covering the electrical aspects of wind turbine systems, including electrical machines, power electronics and power systems.

The PhD course will include basic knowledge of electrical systems of wind power conversion systems, and operation and control in power systems with high level wind power penetration. Some of the course contents are based on recently obtained research results.

The main topics are as follows:

- Overview of electrical systems of wind energy conversion systems
- Wind power generators
- Configuration and control of power electronic conversion system
- Operation and control of wind turbines and wind farms
- Parameter estimation, monitoring and diagnosis of wind turbine systems
- Offshore wind farms and electrical system optimisation
- Wind turbines in power systems

Prerequisites: General knowledge in electrical engineering, preferably have a background at graduate level in electrical engineering.

Modeling and optimization of thermal systems

Organiser:	Associate Professor Mads Pagh Nielsen, mpn@et.aau.dk, Aalborg University
Lecturers:	Associate Professor Mads Pagh Nielsen, Aalborg University and possibly other internal or external guest lecturers.
ECTS:	2
Date:	13 - 15 November 2017
Place:	Aalborg University
Max. no. of participants:	No.

Description:

The focus of this course will be the modelling and optimization of thermal energy systems including:

- Methods for modelling of thermal and calorimetric properties
- Formulation and solution of thermal system models considering partial load
- Parametric optimization of thermal systems
- Topology optimization of thermal systems (for instance the optimization of heat exchanger networks)

Examples will be given mainly in the Energy Technology area in terms of journals – but most of it has a generic structure in terms of peer review process.

Modern Power Semiconductors and their Packaging

Organizer:	Professor Francesco Iannuzzo, fia@et.aau.dk, Aalborg University
Lecturers:	Professor Eckart Hoene, Fraunhofer IZM; Professor Francesco Iannuzzo, Aalborg University, Professor Kjeld Pedersen, Aalborg Universitet, Professor Vladimir Popok, Aalborg University
ECTS:	3
Date/time:	31 October - 3 November 2017, all days 8:30 – 16:30
Max. no. of participants:	20

Description: the main component of modern Power Electronics circuits is the semiconductor power switch. This course presents the fundamentals of Power Switches operations from a physical point of view, together with the specific peculiarities and the reason to use them in a special application.
An overview on different packaging technologies and their properties, advantages and disadvantages, is also given. Requirements from the applications and possibilities to tackle them with a semiconductor package solution will be proposed.

Part I) semiconductor theory
This part aims to give an understanding of semiconductor power switch operations. A preliminary introduction to the PN junction and fundamentals of bipolar junction and field-effect transistors will be given. Then, a comparison between traditional semiconductor technologies, like Silicon, and emerging technologies like GaN and SiC will follow. Successively, referring to MOSFETs and IGBTs, several details about the structure of the elementary cell will be introduced together with the explanation of the fundamental mechanisms taking place during operations, like the Miller plateau, voltage/current overshoot and voltage/current tail. An overview of abnormal operations, like unclamped inductive switching (UIS) and short circuit, together with typical unstable phenomenon like current crowding and thermal runaway, will be also discussed. Finally, modern driving strategies, including two-level turn off and anti-desaturation will be introduced.

Part II) packaging theory
This part aims to introduce, analyze and discuss packaging techniques for modern semiconductor power switches. The present challenges in terms of power density, stray inductance and resistance, and reliability issues will be broadly discussed from a physics point of view, together with several sample applications. Modern interconnection solutions will be presented together with the research challenges in the field of power electronics packaging like copper bond wires, low-profile packaging, bondless packaging, etc.

Task: The participants will be grouped and asked to team work on a real design. A final 1-day lecture is included where groups will compare and deeply discuss the achievements and the design choices.

Prerequisites: basic knowledge of circuit theory

Modular Multilevel Converters MMC

Organizer: Professor Remus Teodorescu, ret@et.aau.dk, Aalborg University

Lecturers: Professor Remus Teodorescu, Aalborg University, Associate Professor Laszlo Mathe, Aalborg University, Associate Professor Sanjay K Chaudhary, Aalborg University

ECTS: 4

Time: 28 November – 1 December 2017

Max. no. of participants: 16

Description:

MMC has been established as the technology of choice for HVDC, large utility scale STATCOM and Multil-MW drives. This course will present the fundamentals, dynamics, modelling and simulation, modulation, control and balancing as well as control under unbalanced grid. Control and operation challenges for MMC application in HVDC, STATCOM and DRIVES will be also presented. The course structure is:

Day 1: MMC fundamentals, topologies and design

Day 2: Modulation techniques (PSPWM, NLC+Sorting, Model Predictive Sorting)

Day 3: Control and balancing

Day 4 Applications of MMC (HVDC, STATCOM, DRIVES)

Around 40 % of the time will be spent in the state of the art MMC Laboratory where the course attendees can program and test 4 dspace controlled MMC setups

Prerequisites:

Power Electronics, Matlab/Simulink or PLECS

Optimization Strategies and Energy Management Systems

Organizer:	Associate Professor Juan C. Vasquez, juq@et.aau.dk, Aalborg University
	Professor Josep M. Guerrero, joz@et.aau.dk, Aalborg University
Lecturers:	Associate Professor Moises Graells (Technical University of Catalonia),
	Associate Professor Eleonora Riva Sanseverino (University of Palermo), Postdoc
	Lexuan Meng, Postdoc Amjad Anvari-Moghaddam
ECTS:	3
Date:	3 – 5 May 2017
Max no. of participants:	20

Description: Energy is a resource that needs to be managed and decisions need to be made on production, storage, distribution and consumption of energy. Determining how much to produce, where and when, and assigning resources to needs in the most efficient way is a problem that has been addressed in several fields. There are available tools that can be used to formulate and solve these kinds of problems. Using them in planning, operation and control of energy systems requires starting with the basics of math programming techniques, addressing some standard optimization problems, and adapting the solutions to new particular situations of interest.

A first issue is revisiting the modelling concept. The model is a simplified and limited representation of our reality. Complex multi-level problems may need different models and models valid at the operational level (operation and control) may not be useful at the tactical or strategic levels (scheduling and planning). Thus, when addressing optimization problems, detailed physical models based on differential equations will be replaced by algebraic equations expressing the basic relations between lumped parameters. The second issue is the choice of a problem-solving method. It is well known that all optimization methods have at least some limitations and there is no single method or algorithm that works best on all or even a broad class of problems. In order to choose the best method for a given problem, one must first understand the nature of the problem and the type of design space that is being searched.

Students attending this course will learn how to recognise and formulate different optimization problems in planning, operation and control of energy systems, and how to solve them using existing softwares and solvers such as MATLAB, GAMS, and Excel. Different principal algorithms for linear, network, discrete, nonlinear and dynamic optimization are introduced and related methodologies together with underlying mathematical structures are described accordingly. Several illustrative examples and optimization problems, ranging from the classical optimization problems to the recent MINLP models proposed for the optimization of integrated energy systems (such as residential AC/DC microgrids) will be introduced during supervised hand-on sessions and different tools (such as classic mathematical methods, heuristics and meta-heuristics) will be used for solving the cases. The choice of objective functions, representation of discrete decisions, using formulation tricks and checking the results will be also covered.

The course is intended for those students that, having a general knowledge in mathematics and simulation, have a very limited experience in math optimization and programming, and need to be introduced to these tools for energy systems optimization.

Prerequisites Familiarity with basics of real analysis, linear algebra, and probability and statistics.

Power Quality in Microgrids

Organizer: Associate Professor Juan C. Vasquez, juq@et.aau.dk, Aalborg University

Professor Josep M. Guerrero, joz@et.aau.dk, Aalborg University

Lecturers: Professor Josep M. Guerrero, Aalborg University, Postdoc Mehdi Savaghebi, Aalborg University, Assistant Professor Joaquin Eloy-Garcia, Carlos III University of Madrid, Assistant Lecturer Alexander Micallef, University of Malta, Francisco Freijedo, École polytechnique fédérale de Lausanne EPFL, Switzerland

ECTS: 3

Date: 26 – 28 April 2017

Max no. of participants: 20

Description: Microgrids are deemed as one of the main building blocks of the smart grids; since, are able to facilitate implementation of many smart grid functions. It is expected that in a near future, smart grid emerges as a well-planned plug-and-play integration of Microgrids which interact through dedicated highways for exchanging commands, data, and power. Providing a high power quality for the customers is one of the main objectives in smart grids.

On the other hand, the proliferation of different nonlinear and single-phase loads in electrical systems has resulted in voltage harmonic and unbalance as two common power quality problems. In addition, harmonic resonances can be excited giving rise to significant increase of the voltage distortion. These phenomena can cause variety of problems such as protective relays malfunction, overheating of motors and transformers and failure of power factor correction capacitors.

In this course, measurement, compensation and damping of such power quality problems will be addressed through several control approaches. Both three-phase and single-phase voltage source inverters will be considered. The modelling and control of these power electronic converters are discussed and hierarchical and decentralized control approaches are presented in order to enhance the voltage quality. Several simulation exercises will be included in labs which cover about 50% of the course time.

Prerequisites: Matlab/Simulink knowledge is recommended for the exercises.

Power System Stability and Control

Organizer: Professor Claus Leth Bak, clb@et.aau.dk, Aalborg University and Dr. Wojciech

Wiechowski ,Commercial and OFTO Transaction Manager at RWE Innogy - RWE Innogy UK Ltd

Lecturers: Dr. Prabha Kundur, President, Kundur Power Systems Solutions Inc. - Canada

ECTS: 4

Date: June 6 – 9 2017

Max no. of participants: 30

Description:
Special Focus of the Course:
The content of this course will be tailored to cover the folllowing topics
in more detail:
– Subsynchronous resonance – modeling and analysis
w/ and w/o power electronic converters.
– Stability and control of single- and multiple-machine systems.
– Stability of HVDC systems – multi-infeed and multi-terminal
LCC- and VSC-HVDC systems.
– Modeling and analysis of the stability impact of different types of
loads, such as induction motors, constant power loads, etc.
– Voltage stability – modeling and analysis, impacts of LCCand
VSC-HVDC systems, and wind power plants.
– Bulk offshore wind power integration.
– The need for spinning reserves.

The course aims at both academia and industry.

Prerequisites: Power System Engineering background theoretical/practical.

Organizer: Professor Claus Leth Bak, clb@et.aau.dk, Aalborg University and Dr. Wojciech
Wiechowski, Commercial and OFTO Transaction Manager at RWE Innogy - RWE Innogy UK Ltd

Welcome Dinner:
Welcome dinner will take place in the evening of 6th June at one of the nice restaurants in Aalborg. This dinner will enable you to get to know other course participants in an informal way. Do take the opportunity to have a delicious dinner and enjoy an informal get together! Welcome dinner is included in the price for industry participants and foreign PhD students.

COURSE MATERIALS:
Course slides / materials will be provided in electronic form. In addition, the Power System Stability and Control Book by Prabha Kundur can be purchased at 750 DKK/copy – please inform if you would like to purchase the book when registering.

Link: http://www.et.aau.dk/phd/phd-courses/

Preparation of Research Plan for Ph.D.'s

Organizer: Professor Frede Blaabjerg, fbl@et.aau.dk, Aalborg University

Lecturers: Professor Frede Blaabjerg, Aalborg University
Associate Professor Chungen Yin, Aalborg University

ECTS: 1

Date: 10 March 2017 or 6 October 2017

Max. no. of participants: 25

Description:

The objective of this one-day PhD course is to provide a presentation on how to make a good study plan. A PhD study plan typically consists of the following sections: (1) project summary; (2) scientific content of the PhD project, including background, state-of-the-art literature review, objectives, key methods, expected outcome, time schedule and milestone, outline and structure of the PhD thesis, publication strategy and tentative titles of papers; (3) collaboration agreement between supervisor and student; (4) plan for PhD courses; (5) plan for fulfillment of knowledge dissemination; (6) agreements on immaterial rights to patents; (7) plan for external collaboration; (8) financial budget for the project; and (9) reference list.

As a relatively new PhD student, it is hardly possible to give a full and clear description of what you will do and how you will do in the coming three years. You may only have some vague ideas about your project. This course will help you to settle these problems as quickly and as well as possible via an effective literature study. A literature study is not only a potted summary of who did what. You need to find their similarities/difference, point out their contributions and flaws in methodology or gaps in research, and outline what you can utilize and what you can improve in your project. A good literature study will make your ideas about your project clearer and clearer, based on which you can start to write up your study plan, with well-defined what to do, why to do and how to do.
We will also go around different data-bases to get the latest impact research in the field by using e.g.
Web of Science, Scopus and Google Scholar as well as discuss how to make efficient time-planning

Photovoltaic Power Systems - in theory and practice

Organizer: Associate Professor Dezso Sera, des@et.aau.dk, Aalborg University

Lecturers: Professor Remus Teodorescu, Aalborg University, Associate Professor Dezso Sera, Aalborg University, Associate Professor Tamas Kerekes, Aalborg University, Associate Professor Laszlo Mathe, Aalborg University , Postdoc Sergiu Spataru, Aalborg University and Rasmus Rode Mosbæk (Lithium Balance A/S)

ECTS: 4

Date: 17-20 October 2017, 08:30-16:30

Max no. of participants: 25

Description: The objective of this course is to give an understanding of the operation, design and control of Photovoltaic Power Systems, and to provide insight into some of the key challenges for higher penetration of photovoltaic energy into the electricity network.
The target audience is PhD students and practicing engineers but also researchers who aim to receive a comprehensive overview of modern photovoltaic systems.
The course is structured in four days, covering topics from PV panels through power electronics and their control to PV plant design and grid integration challenges. An industrial guest lecture on Battery Energy Storage Systems for photovoltaic applications will be included. The mornings are dedicated to lectures, while the afternoons are spent with exercises.
No less than 40% of the course time is spent in the state-of-the-art Photovoltaic Systems laboratory at the Department of Energy Technology at Aalborg University. The participants will make design, simulations and experimental tests, using the following advanced setups:

- Grid-connected PV inverter systems, with real-time control using dSpace® platform. The participants will be able to design, experimentally test, and tune parameters of grid controllers, PLL, voltage support, using the real-time graphical user interface Control Desk®
- Real-time simulation platform on dSpace® system, to design and analyse PLL MPPT
- High performance Spi-Sun 5600 SLP Solar simulator from Spire. Demonstration of PV panel measurements and characterisations will be provided
- Detailed Simulink®, PLECS® and Matlab® GUI models for designing and analysing PV inverter topologies, grid synchronisation and PV array modelling
- PVSyst Software platform for designing PV plants.

Selected simulation models will be included in the course material for the participants.

Prerequisites: A degree in electrical engineering or control engineering and Matlab/Simulink knowledge is strongly recommended. The course language is English.
Link 1 http://www.et.aau.dk/research-programmes/photovoltaic-systems/phd-courses/

Reliability in Power Electronics Systems

Organizer: Professor Frede Blaabjerg, fbl@et.aau.dk, Aalborg University

Lecturers: Professor Frede Blaabjerg, Associate Professor Huai Wang, Aalborg University , Professor Francesco Iannuzzo, Aalborg University, Reliability Advisor Peter de Place Rimmen

ECTS: 3

Date/Time: 11 – 13 October 2017

Max no. of participants: 30

Description:

The course will be the latest research outcomes of the Center of Reliable Power Electronics (CORPE). The 2017 version of the course will focus on failure mechanisms and degradation models of active power devices and capacitors, reliability analysis of power electronic systems, and reliability testing methods. The course will have the following five main parts:

1) Introduction to modern reliability and robustness approach
2) Reliability testing methods and testing data analysis (e.g., Weibull)
3) Long-term wear out and single-event abnormal operation of active power modules and capacitors
4) Design tools and reliability analysis of power electronic systems
5) Condition monitoring and thermal control of critical power electronic components

Prerequisites:

Basic understanding of power electronics, power semiconductor devices, capacitors, and basic statistics.

Reluctance electric motor drives for high efficiency in line –start and variable speed applications

Organizer: Professor Frede Blaabjerg,fbl@et.aau.dk, Aalborg University

Lecturers: Professor Ion Boldea, University Politehnica Timisoara, Romania

ECTS: 2.5

Time: 7 - 8 November 2017

Max. no. of participants: 30

Description: The need for higher efficiency motors at reasonable initial costs for line start and for variable speed applications is growing by the day. The high cost of high energy PMs has prompted vigorous R&D in Academia and Industry worldwide in "Reluctance electric machines which use less high energy PMs (per Nm), or low cost Ferrite- PMs for still higher efficiency than in IMs, for competitive torque/volume and at reasonable costs". Recently ,Reluctance Synchronous Motor (RSM)variable speed drive reached wide markets from 10 to 500(even 1500)Kw power in 4 pole multiple flux barrier cageless rotors, with distributed stator windings; the same is true for line start 3 and 1 phase cage-rotor reluctance PM line start small motors in home appliances. The present Course presents the Status and Trends in Reluctance electric machine drives(REMDs), for line start and variable speed as follows:

Outline

Principles, classifications, merits and demerits of:

- Reluctance synchronous motor drives with cageless an cage rotors without and with PMs

- Flux- modulation REMDS: Flux –modulation principle and its application to Switching -Flux, Vernier, Flux-Reversal, Transverse-Flux, Dual- Rotor Flux- Modulation motor/generator drives(with magnetic gear effects)

- 3- and 1-phase line start Reluctance Synchronous motors without and with PMs for high efficiency ,mainly in small power applications; modeling and design with sample simulation and test results

- 3-Phase Reluctance synchronous motor variable speed drives : modeling, optimal design and control: with case studies

- Ferrite- PM- claw- pole- rotor Synchronous Motor drives design and control with sample results of high torque density and high efficiency

- BLDC-MRM(multiphase reluctance motor) drives design and control with case study and experimental results of 4/1 CPSR

- Brushless Doubly Fed Reluctance machine(B-DFRM) drive: design and control for wind energy

- Switching- Flux(double saliency) machine drives with PMs and(or) dc stator excitation for wide CPSR; modeling and control with illustrative implementation examples

- Vernier PM machine drives with higher power factor and high torque density and reasonable efficiency and cost in low speed high torque applications: with case study

- Transverse –Flux machine drives with stator or rotor PMs and without PMs for high torque density, high efficiency at moderate power factor and initial costs in low speed applications

- Flux Reversal machine drives with double saliency, stator or rotor PMs and 6(12) stator non-overlapping multi-pole-span ac coils for 3 phase implementation ;with sample results
- Dual Rotor Flux-Modulation machine drives with rotor and or stator PMs and magnetic gear (torque magnification)effects for very low speed high torque direct(pseudo-direct) drives; with sample representative results

Renewable Energy based Integrated Energy Systems

Organizer: Professor Zhe Chen, zch@et.aau.dk, Aalborg University

Lecturers: Professor Zhe Chen, Aalborg University, Assistant Professor Chi Su, Aalborg University, Associate Professor Weihao Hu, Aalborg University, Assistant Professor Fujin Deng, Aalborg University, Assistant Professor Jiakun Fang, Aalborg University

ECTS: 3

Date: 13 - 15 February 2017

Max no. of participants: 30

Description:

The course will provide training and education on the subject of renewable energy based integrated energy systems.

The Ph.D. course will include fundamental knowledge of energy sources, energy conversion systems, renewable energy integration, transmission, and distribution. Basic techniques of analysis, operation and control will be presented. The market issue will also be introduced. Some contents are based on up-to-date research results.

The main topics are as follows:

- Overview of modern energy resources and systems
- Basics of energy conversion systems
- Advanced technologies and emerging facilities for energy system integration
- Optimization techniques applied in integrated energy systems
- Impact of renewable power integration and mitigation methods
- Future energy market with significant renewable energy penetration
- Renewable energy transmission: operation and control

Prerequisites: General knowledge in electrical AC circuits and electrical power engineering, preferably background at the graduate level in power systems. Exercises involve Matlab.

Resources and technology pathways for Advanced Biofuels

Organizer:	Associate Professor Jens Bo Holm-Nielsen jhn@et.aau.dk, Aalborg University
Lecturers:	Professor Lasse Aistrup Rosendahl, Aalborg University, Associate Professor Saqib Sohail Toor, Aalborg University and Postdoc Katharina P. Meyer, Aalborg University
ECTS:	5
Time:	27 – 31 March 2017
Place:	Aalborg University, Esbjerg
Max. no. of participants:	30

Description: The course will give an overview of biomass resource study and mapping; sustainability; types of biomass (e.g. woody biomass, forest residues, agricultural residues, energy crops and algaes etc.); pretreatment & characteristics; biomass conversion technologies; themochemical (hydrothermal liquefaction, pyrolysis, gasification) and biochemical (anaerobic digestion) conversion processes; advanced biofuels from biomass; liquid fuels (bioethanol, biodiesel, synthetic fuels from biocrude, drop-in fuels); biogas and methanization; value-added processing of biofuel residues; economic and environmental assessments; policies and future R&D.

- The role of biomass resources in the global renewable energy supply.
- Substrate characteristics & pretreatment methods.
- Sustainablity & biomass mapping.
- Introduction to GIS (Geographic Information System).
- Energy conversion processes and conversion technologies (hydrothermal liquefaction and anaerobic digestion etc.).
- Jet-A-fuels production by conversion of lignocellulosic or algae feedstock's
- Biorefinery production of advanced biofuels and other medium to high value refinery products

Smart Distribution Systems

Organizer: Professor Birgitte Bak-Jensen, bbj@et.aau.dk, Aalborg University

Lecturers: Professor Birgitte Bak-Jensen, Aalborg University, Associate Professor Jayakrishnan Pillai, Aalborg University, Associate Professor Rasmus Løvenstein Olsen, Department of Electronic Systems, Aalborg University, Associate Professor Weihao Hu, Aalborg University, Postdoc Pavani Ponnaganti, Aalborg University, Associate Professor Florin Iov, Aalborg University

ECTS: 3

Date: 12 September – 15 September 2017

Max no. of participants: 20

Description:
The Smart Grid concept involves integration of information and communication technology from the electricity generation to the consumption sectors. The bulk of the smart grid applications take place in the distribution grids (MV and LV) where significant amounts of renewable generation and flexible demand units are integrated, distribution controls are automated, assets are monitored and proactively managed and consumers are empowered for economic and efficient use of electricity.

This course covers important applications and technologies of the smart distribution systems. The technical limitations and means of increasing the hosting capacity of distributed energy resources in intelligent grids are covered.

In addition, the course also includes utility practices and guidelines, dynamics of electricity market, communication technologies and case studies relevant to future power distribution systems.

Following topics are covered in the course:

- Modern Distribution Systems.
- Smart grid fundamentals and concepts.
- Market aspects and demand side management in Smart Distribution Systems.
- Grid codes/standards - LV/MV Distribution systems and operation.
- Operation, control and reliability of DER units in the distribution grids.
- Electric vehicles, Heat pumps, Electric boilers, Solar PVs in distribution grids.
- Communication technologies and standards in Smart Distribution grids.
- Simulation tools for distribution systems, examples with DigSilent.

Prerequisites: Electrical engineers and PhD students with knowledge about electrical power and energy systems.

Stability and Control of Grid-Connected Voltage-Source Converters

Organizer: Assistant Professor Xiongfei Wang, xwa@et.aau.dk, Aalborg University

Lecturers: Assistant Professor Xiongfei Wang, Aalborg University and Lennart Harnefors, Adjunct Professor of Power Electronics KTH - Sweden

ECTS: 3

Date: 15-17 May 2017

Max no. of participants: 35

Description: Voltage Source Converters (VSCs) have commonly been used with renewable power sources, flexible ac and dc power transmission or distribution systems, regenerative drives, and transportation electrification. As the increasing use of VSCs in electrical grids, the dynamic characterizations of VSCs are playing a critical role in building a stable and resilient power-electronic-based power system. This course thus devotes to cover the fundamentals and state-of-the-art of modeling, stability analysis, and control topics for the VSCs in the grid-connected applications.

1. Vector control and current control of VSCs
2. Impedance-based modeling and stability analysis of VSCs
3. Stability impact of grid-synchronization and dc-link voltage control
4. Modular multilevel converters and their internal dynamics
5. Active stabilizing techniques for VSC-fed systems

Prerequisites:

Prior knowledge of power electronics fundamentals, feedback control theory, and three-phase systems is preferred.

Stability of Modern Power Systems with High Penetration of Renewable Energy

Organizer: Associate Professor Sanjay K Chaudhary, skc@et.aau.dk, Aalborg University

Lecturers: Associate Professor Jayakrishnan Radhakrishna Pillai, Aalborg University, Associate Professor Sanjay K. Chaudhary, Aalborg University and Assistant Professor Bakhtyar Hoseinzadeh, Aalborg University

ECTS: 3

Date: 18 - 20 September 2017

Max. no. of participants: 30

Description: This course deals with the stability and control of modern power systems with a high penetration of renewable energy sources.

Power system is undergoing tremendous transformation as non-conventional renewable energy sources like wind and photovoltaic are introduced. While such renewable sources are very good for the sustainable harnessing of energy, they are altering the way power system was designed to operate. First of all they are inherently stochastic in nature due to their dependence upon local weather conditions and secondly they do not use the conventional large synchronous generators. Their power electronic converter interface decouples them from the grid frequency interaction with respect to inertial response and synchronizing power. Moreover, their dependency upon weather may lead to wide variations in power generation capability. At the same time, they might not contribute to the grid frequency stability; especially if they are on maximum power point tracking control. In the event of faults, they have limited power to contribute to the short circuit currents.

On the positive side, the advances in power electronic converter controls, imparts them fast controllability. So they can be controlled to inject reactive current and assist voltage voltage stability. They may also be controlled to provide emulated inertia and primary frequency regulation provided that they have some energy storage.

Key topics include:

- Review of concepts of power system stability
- Frequency and voltage stability with a high penetration of wind and PV power
- Control opportunities and limitations provided by the converter control in RES.
- The concepts would be demonstrated through the appropriate simulation tools like PSCAD and/or DigSILENT.

Prerequisites: A basic knowledge of modern power system.

Storage Systems based on Li-ion Batteries for Grid Support and Automotive Applications

Organizer:	Professor Remus Teodorescu, ret@et.aau.dk, Aalborg University
Lecturers:	Professor Remus Teodorescu, Aalborg University, Dr. Maciej Swierczynski, Aalborg University Dr. Daniel Stroe, Aalborg University, Dr. Erik Schaltz, Aalborg University
ECTS:	4
Date:	24-27 October 2017
Participants:	Max. 20

Description:
The importance of the li-ion batteries is booming and after dominating portable electronics applications, they are entering into new sectors like grid support applications and propelling of the electric vehicles. The penetration of renewables in the power system is considered to significantly increase in near future; thus, batteries can play a crucial role in the reliable and cost efficient grid-integration of intermittent energy sources. Besides, the grid support applications, li-ion batteries have begun to play a major role in the automotive market. The use of batteries in automotive applications is a promising option in order to replace the internal combustion engine cars with ideally, zero emissions vehicles (full electric vehicles), or with controlled emission vehicles (hybrid electric vehicles and plug-in hybrid electric vehicles).
The course is divided into 3.5 days as follows:

DAY1: (Battery technologies and grid applications)
During that first day, state of the art on the energy storage technologies will be provided with special focus on the li-ion batteries. Moreover, the services that the energy storage can provide for grid applications will be discussed. This will be followed by an industrial lecturer presentation and Matlab exercise on optimal sizing of storage in different stationary applications.

DAY2: (Li-ion batteries fundamentals, testing and performance modelling)
The second day focuses on lithium ion battery technology. The operating principles, various chemistries as well as lithium ion batteries laboratory testing and performance modeling will be presented. Simulation studies in Matlab will be performed, where course participants will develop their own performance model of the Li-ion battery.

DAY3: (Automotive applications)
The third day is devoted to automotive applications. Lithium ion technologies for automotive applications will be discussed. Aspects related to li-ion battery management systems for vehicles will be covered. Moreover, sizing and control of battery powered vehicles will be addressed. Third day will be finished with the exercise on li-ion battery powered vehicle.

DAY4: (Lifetime of Li-ion batteries)
The last day is dedicated to the performance degradation and lifetime estimation of Li-ion batteries. Ageing phenomena, accelerated lifetime testing and lifetime modeling of Li-ion batteries will be covered.

Prerequisites: Basic experience
in Matlab/Simulink

Underground and Submarine Power Cables

Organizer: Associate Professor Filipe Miguel Faria da Silva, ffs@et.aau.dk, Aalborg University

Lecturers: Associate Professor Filipe Miguel Faria da Silva, Aalborg University + Dong Person + Energinet.dk Person

ECTS: 3

Date: 5 – 7 April 2017

Max no. of participants: 20

Description: The installation of power cables at HV levels became more common in recent years, with Denmark being one of the countries with a larger percentage of HVAC cables. The reasons for the increasing installation of cables go from the public resistance to overhead lines (OHL) to the need of connecting offshore wind farms, something only possible using submarine cables. Denmark has an ambitious plan of exchange all its 132kV and 150kV OHLs by cables before the end of 2030. Such ambitious plan will affect the operation of the power system, by introducing new phenomena resultant of the different electrical parameters of the cables when compared with OHLs.

This course will address different topics related with installation and operation of underground and submarine HV cables, from their design to the more advance electromagnetic behaviour. Several of the topics presented in the course are areas of research today and the most recent state-of-the-art will be presented for the different topics, based on existing industry procedures and recommendations from international engineering associations as Cigré. The topics of course are:

- Fundamentals of underground and submarine cables;
- Installation of underground and submarine cables;
- Modelling of cables for steady-state, dynamics and electromagnetic transient phenomena;
- Thermal studies of power cables;
- Reactive power compensation of power cables;
- Study of electrical phenomena characteristic of power cables including hybrid cable-OHL lines;
- Protection of power cables and setting of relays;
- Harmonics propagation in power cables and resonances;

Prerequisites: Degree in Electrical Power System or similar

Understand how to write good papers for high level journals

Organizer:	Associate Professor Kaiyuan Lu, klu@et.aau.dk, Aalborg University
Lecturers:	Professor Frede Blaabjerg, Aalborg University and Associate Professor Kaiyuan Lu, Aalborg University
ECTS:	1.5
Date:	22 – 23 May 2017
Max. no. of participants:	NO

Description:

Publication in good journals is a sign of high international recognition of your work. Writing good papers that can be accepted for publication on high level journals are one of the important tasks during a Ph. D. study. This course tries to help the Ph. D. students to increase their chances to get their papers published in international journals. To serve the goal, in this course

- First, the procedure about how the paper review process is carried out will be explained (starting from the moment you submit your paper to the time that you get the reviewers' comments and until the final decision).
- How will a reviewer review a paper.
- Standard evaluation forms that will be filled in by the reviewers for different journals.
- Important aspects to consider when you write your paper. (Paper structure, what to do and what not to do)
- How to include citations to other work in a paper
- How to write the reply to the response from reviewer.
- Case study.
- Exercises and discussions.

Examples will be given mainly in the Energy Technology area in terms of journals – but most of it has a generic structure in terms of peer review process.

Wide-Area Monitoring and Control of Smart Transmission Systems

Organizer: Professor Zhe Chen, zch@et.aau.dk, Aalborg University
Chi Su, Assistant Professor, csu@et.aau.dk, Aalborg University

Lecturers: Associate Professor Luigi Vanfretti - Royal Institute of Technology - Sweden

ECTS: 2

Date: 13 - 14 June 2017

Max no. of participants: 30

Description: This course provides a detailed description on the simulation, stability analysis and control of power transmission systems using wide-area monitoring systems (WAMS). The content of the course covers simulation tools, measuring and data transfer, analytical methodologies to design novel power system stabilizers, etc.

The topics include

- Modeling and simulation tools for smart transmission systems
- Introduction to the wide-area measuring and data transfer in power systems
- Analysis of electromechanical oscillations in power systems based on phasor measurements
- Design of the WAMS based power system stabilizers

Prerequisites:

- Background in power system stability dynamic and control.
- Fundamental knowledge in control theory.
- Basic skills in simulation of power system for transient stability study.