REM master basic syllabus

Title:
ELK23 Power Electronics in Future Power Systems

Credit value:
3.75 ECTS

Mandatory/Optional:
Optional

Semester:
3

Lecturer/s:
Prof. Elisabetta Tedeschi

University:
NTNU- Norwegian University of Science and Technology

Department:
Department of Electric Power Engineering

Rationale:
The widespread use of power electronic interfaces, required to enable the grid integration of renewable energies and increase the efficiency of electric loads, is completely transforming the traditional power system from being mechanically controlled, to being electronically controlled.
Most of the power flow, from generation to distribution and consumption, is currently processed by ac/dc and dc/dc converters. New converter topologies (such as multilevel converters) have entered the market and their design, operation and control need to be optimized for the specific applications.
The course will cover utility applications, ranging from Flexible AC Transmission (FACTS) devices to High-Voltage Direct Current (HVDC) systems and technology, as well as grid interfaces for Distributed Energy Resources. The role of power electronics for power quality enhancement, including reactive power compensation and harmonic filtering, will also be discussed.
The focus of the course will be on the operating principles, analysis, modeling and control of power electronic systems used in the above-mentioned applications.

Objectives:
The main objective of the course is to provide knowledge on the evolution of the modern power system, whose operation is increasingly challenged by the pervasive penetration of power electronic converters. A supplementary objective is to provide students with the ability to understand the increasing relevance of the role of control systems in relation to power electronics applications.

Skills: *(according to the list of skills provided)*

Subject skills	REM Master Skills						
	L2.1	**L2.2**	**L2.3**	**L2.4**	**L2.5**	**L2.6**	**L2.7**
L3.1. To show a good understanding of the basic concepts associated with the Flexible AC Transmission System (FACTS) technology.	X						
L3.2. To show a good understanding of the basic concepts associated with HVDC Technology and the Custom Power technology and to be able to understand their respective roles in high-voltage transmission system and low-voltage distribution system.	X						
L3.3. To demonstrate knowledge about the basic control techniques used to make the power electronics devices to perform useful work and the ability to use them for basic controller design		X	X				

L3.4 To show a basic understanding of the key role that reactive power and harmonic compensation plays in power systems	X						
L3.5. To acquire new skills, related to the capability of organizing information in the format of technical paper and/or power point presentation						X	X
L3.6. To use communication skills in various formats: e.g. oral presentation and group discussion.					X		

Teaching and learning methods:

The course methodology includes various techniques, such as:

1. Lecture format with oral and audiovisual presentations.
2. Exercises and classroom practices in small groups.
3. Seminars of invited speakers.
4. Open/group discussion under course lecturer's supervision.
5. Individual student presentations in plenum.

Allocation of student time:

	Attendance (classroom, lab,…)	**Non attendance (lecture preparation, self study…)**
Regular Lectures	24 hours	48 hours
Classroom practice	4 hours	5 hours
Guest lectures	2 hours	1 hours

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Assessment:

The procedures for assessment of the course is as follows:

1. By conducting an individual project work during the semester, leading to the submission of a paper-format essay.
2. By conducting a final written exam.

Note: The Assessment rules might vary from year to year. The students will be notified at the beginning of the semester of such changes.

Assessment Matrix:

Subject skills	**Assessment method**				
	Exam	**Presentation**	**Paper**	**…**	**…**
L3.1.	75%		25%		
L3.2.	75%		25%		
L3.3.	75%		25%		
L3.4.			100%		
L3.5.	75%		25%		
L3.6.		100%			

Programme:

Topic 1	• Overview of the course • Historical Review: Power Systems • Flexible AC Transmission Systems (FACTS) (Concepts of power flow control and power system stability, Introduction to FACTS devices, Static VAR Compensators TSSC and TCSC, Phase Angle Regulators), Examples. Distribution (2,5 h theory + 0,5 h exercise)
Topic 2	. Introduction to HVDC systems ▪ HVDC: advantages and disadvantages over HVAC ▪ HVDC applications ▪ HVDC configurations (LCC vs. VSC-based solution, including Multilevel converter solutions) ▪ HVDC control principles Distribution (2,5 h theory + 0,5 h exercise)

Topic 3	Vector Control of Voltage Source Converters
	▪ Analysis and mathematical modelling in stationary and rotating frame
	▪ Control of Voltage Source Converters:
	  ▪ Current control loop design and tuning procedure
	  ▪ DC Voltage control loop design and tuning procedure
	▪ Applications and exercises
	Distribution (6 h theory + 2 h exercises)

Topic 4	. Distributed Energy Systems (DERs) ▪ Effect of DG on distribution systems ▪ Power electronics interfaces for: - Internal Combustion Engines - Micro turbines - Fuel cells - Wind & wave energy systems -Electric vehicles and active loads Distribution (4 h theory)
Topic 5	Reactive Power Compensation and harmonic filtering ▪ Review of state of the art ▪ STATCOM vs. SVC ▪ Harmonics filtering techniques: passive filtering and active filtering Distribution (3 h theory+ 1h exercises)
Topic 6	Power Electronics for Power Quality ▪ Concept of custom power and power quality ▪ Causes of Power Quality degradation ▪ Custom power devices types Distribution (2 h theory)
Topic 7	Integration of power electronics and control: ▪ Application to wave energy Distribution (2 h theory)
Topic 8	Guest lecture from a distinguished professor or professional from the industry on a selected topic relevant to the course content Distribution (2 h seminar)
Topic 9	Students' project presentation and discussion Distribution (2 h presentation/discussion)

Resources:

Classroom, Blackboard, laptop, projector, audio, computer room.

All the material necessary to follow the course is facilitated by the course instructor during the course, through 'eLS' (e-Learning System) platform (known as 'Blackboard').

Bibliography:

Basic textbooks:

- *Hingorani, N.G., Gyugyi, L., Understanding FACTS, concepts and technology of Flexible AC Transmission Systems, IEEE Press*
- *K.R.Padiyar, FACTS Controllers in Power Transmission and Distribution, New Age Intl. Pub. 2008*
- *Mohan, Ned, and Tore M. Undeland. Power electronics: converters, applications, and design. John Wiley & Sons, 2007."*

Deepening bibliography:

- *Hingorani, N.G., "Role of Power Electronics in Future Power Systems," Invited Paper, Proc. of IEEE, Special Issue on Power Electronics, April 1988*
- *R. Adapa, "High-Wire Act: HVdc Technology: The State of the Art," in IEEE Power and Energy Magazine, vol. 10, no. 6, pp. 18-29, Nov.-Dec. 2012.*
- *M. P. Bahrman and B. K. Johnson, "The ABCs of HVDC transmission technologies," in IEEE Power and Energy Magazine, vol. 5, no. 2, pp. 32-44, March-April 2007.*

- *+ other selected papers indicated by the lecturer during the semester*

Further comments:

Deviations: Since the teaching and learning processes are adaptive, there may arise minor deviations in the course schedule and content.