REM master basic syllabus

Title:
TET4190 Power Electronics

Credit value:
7.5 ECTS

Mandatory/Optional:
Optional

Semester:
3

Lecturer/s:
Associate Professor Dimosthenis Peftitsis

University:
NTNU-Norwegian University of Science and Technology

Department:
Department of Electric Power Engineering

Rationale:
Based on the recently released forecasts, the electric energy consumption worldwide will increase by almost 56% until 2040. Almost half of the electricity demand will be generated by renewables, whereas the conventional energy sources (fossil fuels) must be utilized by causing the lowest possible energy losses enabling higher energy efficiencies. Power Electronics will play a key-role in the development of the future electric energy systems. The task of Power Electronics is to process and control the flow of electric energy by supplying voltages and currents in a form that are optimally suited for user loads. The development of state-of-the-art low and high power semiconductor devices, make Power Electronics to hold a leading role in dc/dc, dc/ac and ac/dc electric energy conversion for a wide range of application areas. Such areas are electricity transmission and distribution, renewable energy integration, transportation, household appliances, medium and large-scale industrial equipment, aerospace electronics, medical equipment etc. Individual challenges can be found for each specific application area. However, the biggest challenges in Power Electronics are associated with achieving higher energy efficiencies, higher power densities, higher degree of reliability, immunity against electromagnetic interference (EMI), control stability and robustness etc. In order to deal with the individual challenges, the basis of Power Electronics must be first studied in details. This course focuses on presenting the fundamental Power Electronics Converters concepts along with basics of controlling these systems. The most common applications of Power Electronics are also treated.

Objectives:
The main objective of the course is to give knowledge on the basic theory of power electronic energy conversion including applications within renewable energy, transportation, utility, energy saving and industrial products. A supplementary objective is to provide the student with the ability to simulate power electronic converters.

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 define, model and analyze complex systems within power electronics.	x						
L3.2. To design power electronic converters within Electric Energy Technology and SmartGrids with argument criteria	x						
L3.3. To plan and operate the use of power electronic converters in the present and future electric grid and industrial- and oil installations.		x			x		
L3.4 To work independently and in groups					x	x	
L3.5. To use instruments and equipment in the laboratory			x				x

L3.6. To use computer simulation tools for investigating the performance of various power electronic converters			x				x

Teaching and learning methods:

The course methodology includes various techniques, such as:

1. Lecture format with oral and audiovisual presentations.

2. Exercises and peer assessments.

3. Seminars of invited speakers.

4. Semester project work with report and presentation.

5. Laboratory work with report.

Allocation of student time:

	Attendance (classroom, lab,…)	**Non attendance (lecture preparation, self study…)**
Regular Lectures	48 hours	48 hours
Classroom practice	14 hours	5 hours
Project introduction	2 hours	15 hours
Lab practice	16 hours	14 hours
Guest lectures	4 hours	2 hours

Assessment:

The procedures for assessment of the course is as follows:

1. By conducting an individual project work during the semester (25% of the final grade)

2. By conducting a final written exam (75% of the final grade).

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**	**Project**	**…**	**…**
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 • Introduction to power electronic systems • Fundamental concepts (Static power conversion, power semiconductors, inductor and capacitor response), Examples. Distribution (5 h theory + 1 h exercises)
Topic 2	Line-Frequency Diode Rectifiers ▪ Review of basic electric circuit (single and three-phase diode rectifiers) ▪ Operating modes ▪ Effect of single-phase rectifier on neutral currents in three-phase, four-wire systems ▪ Applications and exercises Distribution (6 h theory + 2 h exercises + 4 h lab)
Topic 3	Line-Frequency Phase-Controlled Rectifiers and Inverters ▪ Review of basic electric circuits (single and three-phase phase-controlled rectifiers and inverters) ▪ Control and operating modes of thyristor converters ▪ Applications and exercises Distribution (6 h theory + 2 h exercises + 4 h lab)
Topic 4	dc/dc Switch-Mode Converters ▪ Control of dc/dc converters ▪ Step-down (buck) converter (basic electric circuit, continuous/discontinuous and boundary operating modes, control) ▪ Step-up (boost) converter (basic electric circuit, continuous/discontinuous and boundary operating modes, control) ▪ Buck-boost converter (basic electric circuit, continuous/discontinuous and boundary operating modes, control) ▪ Applications and exercises Distribution (5 h theory + 3 h exercises + 8h lab)
Topic 5	Switch-Mode dc/ac Inverters ▪ Basic concepts of switch-mode inverters ▪ Single-phase inverters (basic electric circuit, PWM modulation and control) ▪ Three-phase inverters (basic electric circuit, PWM modulation and control) ▪ Rectifier mode of operation ▪ Applications and exercises Distribution (6 h theory + 2 h exercises)
Topic 6	Switching dc Power Supplies ▪ Linear power supplies ▪ Overview of switching power supplies ▪ dc/dc converters with electrical isolation ▪ Designing to meet the power supply specifications (EMI) Distribution (4 h theory + 2 h exercises)
Topic 7	Resonant Converters ▪ Classification of resonant converters ▪ Zero-current switching (ZCS) resonant-switch converters ▪ Zero-voltage switching (ZVS) resonant-switch converters Distribution (4 h theory + 2 h exercises)
Topic 8	Applications of Power Electronics ▪ Induction motor drives ▪ Synchronous motor drives

	▪ Residential and industrial applications ▪ Electric utility applications Distribution (5 h theory)
Topic 9	Guest lectures: ▪ Lecture from distinguished professors or professionals from the industry on a selected topic relevant to the course content Distribution (4 h seminar)
Topic 10	Students' project presentation and discussion Distribution *(2h introduction lecture + 1 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:

N. Mohan, T. M. Undeland and W. Robbins, "Power electronics: converters, applications, and design. John Wiley & Sons, 2007."

+ *printed handouts distributed 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.