KTH Electrical Engineering

COURSE DESCRIPTION

EJ2300 POWER ELECTRONICS

7,5 credits, 1st period, autumn 2012

Introduction

Electricity plays a vital role in supplying energy to computers, electronics, industrial processes, trains and many other applications. They all have in common that the electrical energy has to be converted and controlled in a precise manner. This course provides in depth knowledge of power converter topologies, their characteristics, and principles for their control. The course also covers the basics of modern power semiconductors.

Aim

The aim of the course is to give the students tools to be able to analyse and understand the main circuits that are used for power electronic converters.

After having completed the course the student should be able to:

- describe the operating principle for a general power converter by using the basic equations for an inductor and capacitor.
- calculate important quantities like the average value of the output voltage and the fundamental component of the line current.
- explain different operating conditions.
- outline the control of power converters.
- describe modern power semiconductors, their control, and protection.
- dimension and analyze a simple converter both electrically and thermally.

Course structure and language

There are in total 25 hours of lectures, 18 hours of tutorials and 10 hours of peer assessment. Attendance is not compulsory at lectures and tutorials, but participation at 8 out of 10 hours of peer assessment is required. Lectures and tutorials are given in English. There are 2 compulsory laboratory exercises and 1 compulsory project work.

Tutorials

During the course 9 2h tutorials will be given. The main objective of the tutorials is to show how problems can be solved and to prepare for the written examination. Typically, the problems are solved by a teaching assistant. However, students are encouraged to sign up to solve problems in front of fellow students. For each well-prepared and well-presented solution (max 4) of a problem in front of fellow students **one bonus point will be given on the written examination** (only the examination on 16th of October 2012). To sign up, please contact you tutorial assistant.

Laboratory exercises *(compulsory)*

Lab PE-DC: *DC-DC converters* Lab. ass.: *Dimosthenis Peftitsis*

Lab PE-LC: *Line-commutated converters* Lab. ass.: *Juan Colmenares*

Location: Electrical Machine Laboratory, Teknikringen 33, 1 floor down.
Registration is done at https://www.ee.kth.se/lab. **Students should register before the 12th of September for Lab PE-DC and before 21st of September for Lab PE-LC.**

The laboratory exercises start with a short (10 min) written examination. In order to pass the examination a student must have acquired a knowledge corresponding to the level necessary to perform the preparatory work in the lab handout. For a very well-performed laboratory exercise, **one bonus point** will be given at the final written examination on the 16th of October. This means that a maximum of 2 bonus points from the laboratory exercises can be obtained.

For students not familiar with the Swedish laboratory system, a short introduction is offered on **Thursday 13th of September 15-16 hrs and 16-17 hrs in the laboratory.**

Project work *(compulsory)*

Proj. PE-PD: *Design of a step-down converter.* Teach. ass.: *Noman Ahmed*

The project work is done in groups consisting of 2 students. Each group should prepare its own solution to the design problem but of course discussion among the groups is allowed. A report (2 pages excluding figures) on the project is to be submitted **no later than 10th of October**. After submission, it is compulsory to defend the report at a discussion with a teaching assistant. For a very well-performed projects work, **one bonus point** will be given at the final written examination on the 16th of October.

Necessary files will be down-loadable from *KTH Social.*

Peer assessments *(4 out of 5 required)*

Five peer assessments are scheduled during the course in order to encourage continuous studies. Each student has to attend at least four out of five scheduled peer assessments in order to pass the course.

Web-based learning in power semiconductor components

In order to pass the course the student has to complete a web-based learning activity on power semiconductor components. The web-based activity can be found at: http://bilda.kth.se/

Requirements

In order to pass the course, the student has to participate at 4 out of 5 peer assessments (SEM1; 0,5c), complete the 2 laboratory exercises (LABA; 1c) and the project work (PRO1; 1c), complete the web-based learning in power semiconductors (XUPP; 0,5c), and to sit for a written examination (TEN1; 4,5c). The student is permitted to use a standard mathematical handbook, and a calculator at the exam. The pass mark is 15 out of 30 points. Registration for the exam is compulsory and can be done at https://www.ee.kth.se/lab, between the 24th of September and 5th of October.

Date: Thursday 16th October 2012, 14:00-19:00, rooms: D32, D33, D41, D42

Re-sit: (January) Not scheduled yet.

Additional exam (Fx exam)

Students that are close to pass the exam will be given a second opportunity to pass it. At the additional exam three problems are given. Each problem can give 3 points and to pass the additional exam, 7 out of a total of 9 points are required. Students that are offered an additional exam will be notified when the result of the first exam is presented.

The additional exam will be given on:

Friday 23rd of November 2012, 12:00 to 13:00 in the seminar room Teknikringen 33, 2nd floor.

Course examiner and lecturer

Hans-Peter Nee, tel: 08-790 7781, 070-695 34 70, hansi@kth.se

Student Office (STEX)

Osquldas v. 10 (entrance), tel: 08-790 90 86, stex@s3.kth.se
Monday-Friday 9:30-11:00 and 12:00-14:00.

Course material (Available at the Student Office)

[1] *Mohan/Undeland/Robbins: Power Electronics: Converters, Applications, and Design*, John Wiley & Sons, (0471-42908-2, 2003). Price: SEK 450:-

Required reading:
Chapter 1; 2 (*except* sections 2.7, 9, 11, 12); 3; 5; 6; 7 (*except* 7.6); 8 (*except* 8.3.3); 9.1, 9.3, 9.5; 10 (*project work:* 10.5-8); (*web activity*: 19; 20; 21; 22; 23; 25); (*project work*: 29).

[2] *Course binder in Power Electronics*. Price: SEK 50:-

Complementary course, EJ2420

In parallel to this course, the division offers a seminar course covering related topics. The seminars give an overview of the area and can be highly recommended. See our home-page for further details.

Assistant instructors

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Juan Colmenares, tel: 08-790 9038, juanco@kth.se
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Time schedule

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Lecture 1 Monday 3/9, 10-12, H1	
Introduction, Static power conversion	Ch. 1
Power semiconductors	2.1, 2, 4-6, 8, 10
(Review of basic …	*Ch. 3*
Inductor and capacitor response	3.2.5
Dc-dc converters, step-down, cont. mode	7.1-7.3.1
Lecture 2 Tuesday 4/9, 13-15, H1	
Dc-dc converters, step-down, disc. mode, voltage ripple	7.3.2-7.3.4
Dc-dc converters, step-up	7.4
Time slots for tutorials on Wednesday 5/9 are not used	
Lecture 3 Friday 7/9, 13-15, H1	
Dc-dc converters, buck-boost	7.5
Full-bridge	7.7
Comparison	7.8

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Lecture 4 Monday 10/9, 13-15, H1	
Introduction to the project work	
Dc-dc converters cont.	
Dc-motor drives	13.1-13.6.6
Tutorial 1a Tuesday 11/9, 15-17, Q11	problems: 3.8; 7.1-3, 5, 7
Tutorial 1b Wednesday 12/9, 8-10, E34	problems: 3.8; 7.1-3, 5, 7
Peer assessment 1 Thursday 13/9, 13-15, H1	7.1-7.3.1
DEMONSTRATION of practicalities for the lab work, Thursday 13/9, 15-16, Lab.	
DEMONSTRATION of practicalities for the lab work, Thursday 13/9, 16-17, Lab.	
Lecture 5 Friday 14/9, 8-10, H1	
Review of basic el. circuit	3.1, 3.2
Thyristors	2.3
Diode rectifiers	5.1-5.2
Single-phase diode rectifiers	5.3
Fourier analysis	

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Lecture 6 Monday 17/9, 8-10, H1	
Neutral currents	5.5
Three-phase diode rectifiers	5.6
Single-phase thyristor converters, power aspects	6.1-6.3.1
Lecture 7 Wednesday 19/9, 8-10, H1	
Single-phase thyristor converters	6.3.2-
Three-phase converters	6.4
Tutorial 2a Wednesday 19/9, 15-17, D42	problems: 7.8-16, 18-23
Tutorial 2b Thursday 20/9, 8-10, D33	problems: 7.8-16, 18-23

Tutorial 3a Friday 21/9, 8-10, D32	problems: 13.1, 5; 5.1-7, 19, 21
Tutorial 3b Friday 21/9, 13-15, E33	problems: 13.1, 5; 5.1-7, 19, 21

Lecture 8 Friday 21/9, 15-17, H1

Cooling	Ch. 29
Single-phase inverter, PWM	8.1-8.2
Single-phase inverter, rectifier operation	8.3-8.3.2

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Lecture 9 Monday 24/9, 13-15, H1

Three-phase inverter	8.4
Effect of blanking time in PWM inverters	8.5
Other modulation schemes	8.6
Rectifier mode	8.7

Lecture 10 Tuesday 25/19, 13-15, H1

Resonant converters	9.1, 3, 5
Tutorial 4a Thursday 27/9, 8-10, D33	problems: 5.8-11, 23, 26; 6.1-11
Tutorial 4b Thursday 27/9, 13-15, L41	problems: 5.8-11, 23, 26; 6.1-11
Peer assessment 2 Friday 28/9, 8-10, H1	5.3
Tutorial 5a Friday 28/9, 10-12, L44	problems: 6.11-20; plus extra
Tutorial 5b Friday 28/9, 15-17, E33	problems: 6.11-20; plus extra

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Demonstration Tuesday 2/10, 8-10, LAB
Demonstration of PWM in the lab

Lecture 11 Tuesday 2/10, 13-15, H1

Review of basic magn. circuits	3.3
Switching dc power supplies	10.1-10.4.3
Tutorial 6a Wednesday 3/10, 8-10, L43	problems: 8.1-4
Tutorial 6b Wednesday 3/10, 10-12, D35	problems: 8.1-4
Tutorial 7a Thursday 4/10, 8-10, L43	problems: 8.7-12
Tutorial 7b Thursday 4/10, 13-15, L44	problems: 8.7-12
Peer assessment 3 Friday 5/10, 8-10, H1	5.6

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Lecture 12 Monday 8/10, 15-17, H1

Switching dc power supplies	10.4.4-10.4.8
Recap.	
Tutorial 8a Tuesday 9/10, 8-10, L43	problems: 9.11, 12, 14; 10.2, 3
Tutorial 8b Tuesday 9/10, 13-15, D42	problems: 9.11, 12, 14; 10.2, 3

Peer assessment 4 Wednesday 10/10, 10-12, H1	8.4, 8.7
Peer Assessment 5 Thursday 11/10, 13-15, H1	10.1-10.4
Tutorial 9a Friday 12/10, 8-10, D33	problems: 10.4-8, recap.
Tutorial 9b Friday 12/10, 13-15, D32	problems: 10.4-8, recap.

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Examination Tuesday 16/10, 14-19, D32, D33, D41, D42

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Additional Exam (Fx exam) Friday 23/11, 12-13, seminar room, Teknikringen 33, 2nd floor