KTH Electrical Engineering

COURSE DESCRIPTION

EJ2301 POWER ELECTRONICS

6 credits, periods 1-2, autumn 2015

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 22 hours of lectures, 16 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, 1 compulsory project work, and 1 compulsory web activity.

Distribution of clickers

The clicker devices (clickers) will be distributed by the teaching assistants during the following dates:

• Tuesday 8th of September, 10:00 – 12:00, in lecture room D3.

• Wednesday 9th of September, 13:00 – 15:00, Seminar room, Teknikringen 33, 1 tr.

In order to get a clicker, each student must have register to the course through "My pages".

You can still contact Diane Sadik later in order to get a clicker assigned to you. Note, though, that a late registration will cause you missing bonus points during the past tutorial sessions. It is not possible to register a clicker during a tutorial.

If a clicker is lost, the student has to pay 350 SEK otherwise he/she is not allowed to take the exam.

Tutorials

During the course 8 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 actively participate, using their individual "clickers" to solve a daily quiz of 3-5 questions given by the teaching assistants during each session. In total, 30 questions will be asked during the 8 tutorial sessions, and for every 5 correct answers each student will be given one bonus point (max 5) on the written examination (only the examination on 18th of January 2016).

Laboratory exercises (compulsory)

Lab PE-DC:	*DC-DC converters*	Lab. ass.: *Lebing Jin*
Lab PE-LC:	*Line-commutated converters*	Lab. ass.: *Stefanie Heinig*

Location: Electrical Machines Laboratory, Teknikringen 33, 1 floor down.
Registration to the laboratory exercises should be made on the web following a link which will be sent as a news feed on KTH social. **Students should register at the latest on the 11th of September for Lab PE-DC and ant the latest on the 1st of October 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 18th of January 2016. This means that a maximum of 2 bonus points from the laboratory exercises can be obtained.

Project work (compulsory)

Proj. PE-PD: *Design of a step-down converter.* Teach. ass.: *Matthijs Heuvelmans*

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 1st of December**. After submission, it is compulsory to defend the report at a discussion with a teaching assistant. For a very well-performed project work, **one bonus point** will be given at the final written examination on the 18th of January 2016.

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 (LAB1; 0,5c) and the project work (PRO1; 1c), complete the web-based activity in power semiconductors (XUP1; 0,5c), and to sit for a written examination (TEN1; 3,5c). 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 on the web using a link which will be sent as a news feed on KTH social, **between the 1st and 15th of December**.

Date: Monday 18th January 2016, 14:00-19:00, rooms: M23, M24, M36, M37.

Re-sit:: 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 20th of February 2015, 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@ee.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); 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

Diane Sadik (Course assistant), tel: 073-563 29 11, dianes@kth.se
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Simon Nee tel: 070-447 2010, snee@kth.se

Time schedule

w. 36

Lecture 1 Thursday 3/9, 8-10, Q2	
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 Friday 4/9, 15-17, Q2	
Dc-dc converters, step-down, disc. mode, voltage ripple	7.3.2-7.3.4
Dc-dc converters, step-up	7.4

w. 37

Lecture on Tuesday 8/9, 10-12, D3	**Distribution of clickers to registered sudents.**
Clicker distribution 9/9, 13-15, Seminar room, Teknikringen 33, 2nd floor	
Tutorial 1 Thursday 10/9, 8-10, L41, L42, L43	problems: 3.8; 7.1-3, 5, 7

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Lecture 3 Wednesday 16/9, 10-12, V1	
Dc-dc converters, buck-boost	7.5
Full-bridge	7.7
Comparison	7.8
Tutorial 2 Thursday 17/9, 8-10, L41, L42, L43	problems: 7.8-16, 18-23

w. 39

Peer assessment 1 Thursday 24/9, 8-10, Q2	7.1-7.3.1
Lecture 4 Friday 25/9, 15-17, D3	
Introduction to the project work	
Dc-dc converters cont.	
Dc-motor drives	13.1-13.6.6

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Lecture 5 Monday 28/9, 13-15, D3	
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	
Peer assessment 2 Wednesday 30/9, 10-12, M3	5.3

w. 41

Lecture 6 Wednesday 7/10, 10-12, D3	
Neutral currents	5.5
Three-phase diode rectifiers	5.6
Single-phase thyristor converters, power aspects	6.1-6.3.1
Tutorial 3 Thursday 8/10, 8-10, B22, B23, B24	problems: 13.1, 5; 5.1-7, 19, 21

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Lecture 7 Wednesday 14/10, 10-12, D3	
Single-phase thyristor converters	6.3.2-
Three-phase converters	6.4

Tutorial 4 Thursday 15/10, 8-10, L22, L43, L44	problems: 5.8-11, 23, 26; 6.1-11

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Lecture 8 Wednesday 4/11, 10-12, K1	
Cooling	Ch. 29
Single-phase inverter, PWM	8.1-8.2
Single-phase inverter, rectifier operation	8.3-8.3.2
Tutorial 5 Thursday 5/11, 8-10, D42, E33, E36	problems: 6.11-20; plus extra

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Peer assessment 3 Wednesday 11/11, 10-12, D3	5.6
Tutorial 6 Thursday 12/11, 8-10, B21, B22, B24	problems: 8.1-4

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Lecture 9 Wednesday 18/11, 10-12, 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 Thursday 19/11, 8-10, B3	
Review of basic magn. circuits	3.3
Switching dc power supplies	10.1-10.4.3

w. 48

Tutorial 7 Wednesday 25/11, 10-12, L42, L43, L44	problems: 8.7-12
Peer assessment 4 Thursday 26/11, 8-10, Q2	8.4, 8.7

w. 49

Lecture 11 Wednesday 2/12, 10-12, M3	
Switching dc power supplies	10.4.4-10.4.8
Recap.	
Tutorial 8 Thursday 3/12, 8-10, L41, L42, L43	problems: 10.2-8

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Tutorial 9 Wednesday 9/12, 10-12, B22, B23, B24	**extra slot if necessary**
Peer Assessment 5 Thursday 10/12, 8-10, Q2	10.1-10.4

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Examination Monday 18/1, 14-19, M23, M24, M36, M37

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Additional Exam (Fx exam) Friday 19/2, 12-13, seminar room, Teknikringen 33, 2nd floor