KTH Electrical Engineering

COURSE DESCRIPTION

EJ2301 POWER ELECTRONICS

6 credits, periods 1-2, autumn 2016

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:

• Thursday 1st of September, 08:00 – 10:00, in lecture room D2.

• Tuesday 6th of September, 12:00 – 13:00, in room Q26

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

You can still contact Keijo Jacobs 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 14th of January 2017).

Laboratory exercises (compulsory)

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

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 9th of September for Lab PE-DC and at the latest on the 6th 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 14th of January 2017. 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.: *Ilka Jahn*

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 14th of January 2017.

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: Saturday 14th January 2017, 09:00-14:00, rooms: K51, K53, V12, V35.

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 10th of February 2017, 12:00 to 13:00. Room will be decided later.

Course examiner and lecturer

Hans-Peter Nee, tel: 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

Keijo Jacobs (Course assistant), keijoj@kth.se
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Time schedule

w. 35	
Lecture 1 Wednesday 31/8, 10-12, V2	
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 on Thursday 1/9, 8-10, D2	**Distribution of clickers to registered students.**
w. 36	
Lecture 2 Monday 5/9, 13-15, B23	
Dc-dc converters, step-down, disc. mode, voltage ripple	7.3.2-7.3.4
Dc-dc converters, step-up	7.4
Clicker distribution Tuesday 6/9 12-13, Q26	
Tutorial 1 Wednesday 7/9, 10-12, L41, L42, L43	problems: 3.8; 7.1-3, 5, 7
w.37	
Lecture 3 Monday 12/9, 13-15, B3	
Dc-dc converters, buck-boost	7.5
Full-bridge	7.7
Comparison	7.8
Tutorial 2 Wednesday 14/9, 10-12, M23, M24, M36	problems: 7.8-16, 18-23
w. 38	
Peer assessment 1 Thursday 22/9, 8-10, D3	7.1-7.3.1
Lecture 4 Friday 23/9, 15-17, D3	
Introduction to the project work	
Dc-dc converters cont.	
Dc-motor drives	13.1-13.6.6
w. 39	
Lecture 5 Monday 26/9, 13-15, Q2	
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 Thursday 29/9, 8-10, D3	5.3
w. 40	
Lecture 6 Monday 3/10, 13-15, L1	
Neutral currents	5.5
Three-phase diode rectifiers	5.6
Single-phase thyristor converters, power aspects	6.1-6.3.1
Peer assessment 3 Wednesday 5/10, 10-12, D2	5.6
w. 41	
Lecture 7 Monday 10/10, 13-15, D2	
Single-phase thyristor converters	6.3.2-
Three-phase converters	6.4
Tutorial 3 Wednesday 12/10, 10-12, M23, M24, M35	problems: 13.1, 5; 5.1-7, 19, 21

w. 44

Lecture 8 Thursday 3/11, 8-10, B2	
Cooling	Ch. 29
Single-phase inverter, PWM	8.1-8.2
Single-phase inverter, rectifier operation	8.3-8.3.2
Tutorial 4 Friday 4/11, 15-17, L41, L42, L43	problems: 5.8-11, 23, 26; 6.1-11

w. 45

Peer assessment 4 Wednesday 9/11, 10-12, K1	6.3, 6.4
Tutorial 5 Friday 11/11, 15-17, D32, D33, D35	problems: 6.11-20; plus extra

w. 46

Lecture 9 Monday 14/11, 13-15, D3	
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 17/11, 8-10, B1	
Review of basic magn. circuits	3.3
Switching dc power supplies	10.1-10.4.3

w. 47

Tutorial 6 Monday 21/11, 13-15, K53, L41, L42	problems: 8.1-4
Peer assessment 5 Wednesday 23/11, 10-12, D2	8.4, 8.7

w. 48

Lecture 11 Monday 28/11, 13-15, D2	
Switching dc power supplies	10.4.4-10.4.8
Recap.	
Tutorial 7 Wednesday 30/11, 10-12, D41, E33, E34	problems: 8.7-12

w. 49

Tutorial 8 Monday 5/12, 13-15, L41, L42, L43	problems: 10.2-8
Extra slot if necessary Wednesday 7/12, 10-12, B2	

w. 2 2017

Examination Saturday 14/1, 9-14, K51, K53, V12, V35

w. 6 2017

Additional Exam (Fx exam) Friday 10/2, 12-13, room will be decided later