Power Electronics – Fundamentals

Code 11225.0 A-1. First Semester 2021.

1 Team of Professors

Lectures

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2 Theoretical Part – Planning and Evaluation

2.1 Course Objectives

This course is designed for undergraduate students, with a strong background on electrical engineering and mathematics. The theoretical part of this course provides the student with a general background about important aspects of Power Electronics. This is an introduction course which presents the student an overview of all important aspects regarding Power Electronics topologies, different type of converters and modulation techniques. After the student has approved this course, the following specific goals are expected to be acquired:

1. The student must be able to understand and recognize the operation of different semiconductors used in the industry nowadays.

2. The student must be able to recognize and understand the operation of converter topologies such as rectifiers, inverters and DC/DC converters.

3. The student must be able to understand modulation techniques applied to inverters such as PWM and SVM techniques.

2.2 Lecture Time

The date and time of the lecture will be as follows:

1. Monday, Module 1.
2. Monday, Module 2.

2.3 Prerequisites

Prerequisites of this course are defined by the Electrical Department of the Universidad de Santiago de Chile. Nevertheless, it is important the student has an undergraduate-level understanding of the following topics: Calculus and Differential Equations, Power System Theory, Electronic Systems Theory, Laplace and Fourier Transform, Electrical Signal Theory, Electromagnetism, C Programming and Matlab. In addition, the student must be able to at least understand literature in English.

2.4 Course Outline

Table 1 shows the contents and dates of each lecture.

Table 1. Lectures Outline

Date	Topic	Content
	1	Overview of Power Electronics
	2	Power Electronic Devices
	3	Multipulse Rectifiers based on Diodes and SCRs
	4	DC/DC Converters
	5	PWM for 2-Level Inverter
	6	Space Vector Modulation for 2-Level Inverter
28.05.21	Homework 1	Friday. Until 23:59 hrs.
09.07.21	Homework 2	Friday. Until 23:59 hrs.
13.08.21	Final Project	Friday. Until 23:59 hrs.

2.5 Evaluation

The theoretical part of this course is divided in three evaluations. The first and second evaluation correspond to a collective homework assignment (HW) associated to the topics of the course. The third evaluation corresponds to a final collective project (FP) that aims to cover all the contents studied throughout the course, and especially focused on PLECS simulations and theory, the (FP) is going to be evaluated with a presentation made by each group. The final grade of the course will correspond to the algebraic average of the three mentioned marks. Each evaluation considers a 60% approval scale.

In summary, the evaluations will be as follows:

```
FinalMark = (HomeWork1 + HomeWork2 + FinalProject)/3;
```

The laboratory has an independent mark respect to theory and both has to be approved independently to be graduated from the course.

2.6 Grading Policy

The course graduation policy can be defined as follows:

```
if (FinalMark >= 4.0)
    Return Approved;

else
    Return Go to POR.
```

After POR, new final mark is calculated as follows:

```
Min(Homework1,Homework2,FinalProject) = POR;
NewFinalMark = (HomeWork1 + HomeWork2 + FinalProject)/3;
```

Then:

```
if (NewFinalMark >= 4.0)
    Return Approved;
else
    Return See You Next Semester;
```

2.7 Class Policy

1. Regular attendance is essential and expected.
2. It is suggested that students review the lectures of the bibliography of the class before the class.
3. Academic Honesty. Lack of knowledge of the policy of academic honesty is not a reasonable explanation for a violation. Copying in any way during testing and evaluations may be grounds for expulsion from the University.

3 Simulation and Exercises – Planning

3.1 Course Objectives

The objective of the simulation and exercises is to present and prepare students to perform analysis, modeling, design and simulation of systems based on Power Electronics using PLECS software. The specific objectives of this class are:

1. Introduce and prepare students to perform advanced simulations in PLECS software.
2. To complement the contents studied in the course to link and interiorize these topics in a more direct way through simulation.
3. To prepare the previous and necessary contents to carry out each one of the projects of the course, with the purpose of offering all the necessary tools to carry out each one of them.

3.2 Prerequisites

The prerequisite for the simulations sessions is the previous installation of the PLECS software, that can be downloaded for free from its main site (https://www.plexim.com/download/standalone). The license will be delivered to each student. It is important to note that the software license can only be used on the first computer on which it is entered.

3.3 Lecture Time

The simulation and exercise sessions will take place during the following days:

1. Wednesday, Module 6. Review and Q&A of the weekly lesson.
2. Thursday, Module 4. Review and Q&A of the weekly lesson.

The weekly simulation session will be developed offline and uploaded to the main platform of the course each week. The aforementioned video will contain all the indications to carry out the construction of the simulation. An operational study and Q&A sessions will be conducted during the class schedule. Each student must study and build their own simulation based on the digital session. Additionally, a weekly video exercise will be uploaded to complement the topics studied in the respective week. The first week only contemplates simulation.

3.4 Course Outline

Table 2 displays the contents and dates of each simulation and exercises session.

Table 2. Simulation and Exercises Outline

Week	Date	Topic
1	19.04.21	S00: Introduction to PLECS Simulation
2	26.04.21	S01: Power Devices, Dynamic and Thermal Modeling
3	03.05.21	S02: Six-Pulse Based Power Rectifiers
4	10.05.21	S03: Twelve-Pulse Based Power Rectifiers
5	24.05.21	S04: Buck and Boost Converters
6	31.05.21	S05: Cuk Converter
7	07.06.21	S06: Flyback Converter
8	14.06.21	S07: PWM Applied to a 2-L VSI
9	21.06.21	S08: SVM Applied to a 2-L VSI

3.5 Class Policy

1. Students are expected to actively participate in the simulation experiences so that they can resolve their doubts and complement the activities and questions requested in the respective guide.

2. Since it is not possible to actively monitor the work done by students during the assistantship hours, it is expected that the activities will be carried out with responsibility and honesty, since these will be decisive in proving their knowledge in the evaluation stages of the course.

4 Laboratory – Planning and Evaluation

4.1 Course Objectives

1. The student must be able to understand and recreate a simulation based on Power Electronics and electric devices on PLECS.

2. The student must be able to analyze and explain the entire behavioral of a electric system based on Power Electronics.

4.2 Consultation Time

1. Wednesday, Module 4.

2. Friday, Module 3

4.3 Course Outline

The laboratory section of the course is evaluated only by three simulation projects developed by the same groups formed for the Homeworks, i.e, there is no presential or online lessons, however during the free week are available two blocks for doubt resolutions.

The projects are **Directly Related** with the Simulation and Exercises part of the course and must be delivered by the student groups in the date explicited on Table 3 with a digital report and the simulation of the project.

Table 3. Laboratory Outline

Project	Date	Project Name
1	04.06.21	Rectifiers
2	25.06.21	DC-DC Converter
3	23.07.21	Inverter: SVM and Harmonic Analysis

4.4 Evaluation

The laboratory is divide in three simulation projects, each one of them with the same weight for the final evaluation. Therefore the final mark will be the average of the marks.

The laboratory has an independent mark respect to theory and **both has to be approved to graduate from the course.**

Every laboratory is evaluated with a final digital report and an attached file with the complete and functional PLECS simulation of the project, wich must be delivered.

The weight of the content of each project is specified in the guide delivered. In summary, the evaluations will be as follows:

```
Mark1 = Final_Report1*0.8+Simulation1*0.2;
Mark2 = Final_Report2*0.8+Simulation2*0.2;
Mark3 = Final_Report3*0.8+Simulation3*0.2;
FinalMark = (Mark1+Mark2+Mark3)/3;
```

4.5 Grading Policy

The course graduation policy can be defined as follows:

```
FinalMark = (Mark1+Mark2)/2;
if (FinalMark >= 4.0 && all Marks >= 4.0)
    Return Approved;
else
    Return See you next semester;
```

5 General Information

5.1 Main References

Most of the content of our lecture can be found in the following books:

1. Bin Wu, *High Power Converters and AC Drives*, Wiley IEEE Press, 2006. This book can be downloaded from: http://biblioteca.usach.cl/biblioteca-digital at ***myilibrary*** data base.

2. Erickson, Robert W and Maksimovic, Dragan, *Fundamentals of power electronics*, Springer Science & Business Media, 2007.

The following references can be used as complementary:

1. Ned Mohan, *First Course on Power Electronics and Drives*, MNPERE, 2003.

2. Muhammad Rashid, *Power Electronics Devices, Circuits, and Applications*, Pearson, 2014. This book can be downloaded from: http://biblioteca.usach.cl/biblioteca-digital at ***myilibrary*** data base.

5.2 Communication Media

The official communications media for the course are as follows:

1. Uvirtual. https://uvirtual.usach.cl/moodle/ Code 11225.0

2. LOA. https://loa.usach.cl/intranetfing/

3. E-mail and Google Groups - EDP_1S21. It is important that you use your institutional mail (@usach.cl) with the subject "EDP - Theme", referring to the lecture, the simulation and exercise sessions or the laboratory.

5.3 Homeworks, Laboratory Reports and Projects Submission

The submission of homeworks, laboratory reports and projects must be made through Uvirtual and E-mail on the date and time specified for each case.