67229 - Modeling and Control of Power Electronic Systems

Información del Plan Docente

Academic Year	2016/17
Academic center	110 - Escuela de Ingeniería y Arquitectura
Degree	527 - Master's in Electronic Engineering
ECTS	5.0
Course	1
Period	First semester
Subject Type	Optional
Module	---

1.Basic info

1.1.Recommendations to take this course

1.2.Activities and key dates for the course

2.Initiation

2.1.Learning outcomes that define the subject

2.2.Introduction

3.Context and competences

3.1.Goals

3.2.Context and meaning of the subject in the degree

3.3.Competences

3.4.Importance of learning outcomes

4.Evaluation

5.Activities and resources

5.1.General methodological presentation

The learning process designed for this subject is based on the following:

* The teaching process will involve three main levels: lectures, laboratory problems and, active student participation.
* In the lectures the theoretical basis of averaged switch modelling and Middlebrrok's theorems will be exposed.
* In the classes of problems the students will develop worked-out examples
* Lab practices will be developed in small groups where students perform computer simulations of examples.

67229 - Modeling and Control of Power Electronic Systems

5.2.Learning activities

The program offered to the student aims to help him achieving the expected results and includes the following activities ...

CLASS WORK: 2 ECTS (50 hours)

A01 Master class (22 hours).

Keynote session's presentation of theoretical contents. The concepts and fundamentals of averaged switch modeling and Middlebrrok's theorems, illustrating them with examples will be presented. The student participation is demanded through questions

A02 Problem solving classes (4 hours).

Problems and cases involving students, coordinated at all times with the theoretical contents will be developed. Students are encouraged to work the problems previously.

A03 Lab practices (15 hours).

Practices are structured in 5 sessions of 3 hours each. The statements of the practices will be available to students in the Digital Teaching Ring

A06 Supervised work (9 hours)

Tutoring of student about homework.

TAKE-HOME WORK: 3 ECTS (75 hours)

67229 - Modeling and Control of Power Electronic Systems

A06 Student assignments (20 hours).

They are activities that the student will perform alone or in groups and that the teacher will propose throughout the teaching period. In order to assess the progressive acquisition of knowledge, they will be proposed resolution of a sheet of short questions. The developed work is associated with the lab practices.

A07 Study (35 hours).

This activity includes both personal study aimed at achieving adequate monitoring of the subject, conducting practices, exam preparation and tutoring

A08 Evaluation tests (20 hours).

Midterm exam: one-week take-home exam, to be handed out in class and collected a week later to cover HW #1-4.

Final exam: four-day take-home exam, to be handed out in class and due four days later to cover HW #1-8

5.3.Program

The contents developed in the classroom are as follows:

- T1. Introduction and simulation tools.
- T2. Averaged switch modeling.
- T3: Middlebrook's Extra Element Theorem.
- T4: Middlebrook's feedback theorem.
- T5: Equivalent circuit modeling of the discontinuous conduction mode.
- T6: Peak and average current mode control.

Universidad Zaragoza

67229 - Modeling and Control of Power Electronic Systems

The contents developed in the weekly homework are:

Homework Assignment 1

Averaged switch modeling problems

Do problems 7.15 and 7.16 of the course textbook, second edition.

It is highly suggested that you read Section 7.4 of the textbook before attempting problems 7.15 and 7.16. It is also suggested that you read notes posted in the Matlab/Simulink pages

Simulink problems

Do the attached problems:

- Closed-loop output impedance of buck converter
- Control-to-output transfer function of a buck-boost converter

Homework Assignment 2

Extra Element theorem problems

Do the folowing two problems:

- The effect of capacitor equivalent series resistance (esr) on the transfer function of an R-L-C filter
- Analysis of the CCM buck-boost converter control-to-output transfer function Gvd(s) using the extra element

theorem.

Homework Assignment 3

Extra Element theorem problems

Do the folowing two problems:

- Analisys and design of a CCM SEPIC
- Analisys of a flyback converter with input filter

Homework Assignment 4

The n Extra Element Theorem

Do the following problems:

- Writing the output impedance function of a damped filter circuit
- Writing the control-to-output transfer function of a nonideal boost converter

Homework Assignment 5

The Feedback Theorem and Feedback loop simulation

Do the following two problems:

- Use of the feedback theorem to analyze a transconductance amplifier circuit

67229 - Modeling and Control of Power Electronic Systems

- Simulation of a closed-loop SEPIC

Homework Assignment 6

Discontinuous conduction mode

* Do the following problems:

- Problem 11.3
- Problem 11.4
- Problem 11.6
- Additional 11.6(d): modify your answer to part (c), accounting for inductor high frequency dynamics.

* Do the attached DCM Flyback simulation problem

Homework Assignment 7

Current mode control

Do the following two problems:

- Problem 12.2 of the textbook
- Design on compensator of a closed-loop CPM buck regulator based on the simple model

67229 - Modeling and Control of Power Electronic Systems

Homework Assignment 8

Current mode control, HF model

Analysis and simulation of a CPM Regulator:

- Evaluation of a compensator design
- Simulation
- Compensator redesign based on the more accurate model
- Response to a step change in load current

The contents developed in the problems solving are:

1 Problem 6.45 Modeling and control of a buck converter

2 Problem 6.46 Modeling and control of a bidirectional buck converter

3 Problem 6.48 Modeling and control of a boost converter

4 Problem 6.49 Modeling and control of a flyback converter

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67229 - Modeling and Control of Power Electronic Systems

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Universidad Zaragoza

67229 - Modeling and Control of Power Electronic Systems

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Universidad Zaragoza

67229 - Modeling and Control of Power Electronic Systems

The Feedback Theorem and Feedback loop simulation

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67229 - Modeling and Control of Power Electronic Systems

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5.4.Planning and scheduling

67229 - Modeling and Control of Power Electronic Systems

Lecture schedule and assignments

Lectures and problem classes and practice sessions held in the laboratory are according to schedule set by the academic authorities (schedules available on their website). The other activities will be planned depending on the number of students and will be announced in good time.

The weekly breakdown is as follows:

Week 1:

Introduction

- Introduction to subject.
- Presentation of ideas.

Simulation tools

- Matlab/Simulink tutorial.
- LTspice tutorial.

Week 2:

Averaged switch modeling and simulation

- Section 7.4 and Appendix B.
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Averaged models of main converters.

- Scheme of isolated converters.

Week 3:

- Introduction to Middlebrook's Extra Element Theorem.
- Appendix C.
- EET SEPIC analysis example, Zd.
- Weekly work due 1.

Week 4:

- Introduction to Middlebrook's Extra Element Theorem.
- Appendix C.
- EET SEPIC analysis example, Zn.
- Weekly work due 2.

Week 5:

- Middlebrook's n-Extra Element Theorem.
- Weekly work due 3.
- Lab practice 1.

Week 6:

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Middlebrook's Feedback Theorem.

- Measurement point of transfer functions.
- Analysis of feedback circuits using null double injection techniques (examples
- Weekly work due 4.

Week 7:

- Dynamic modeling and simulation of converters operating in discontinuous conduction mode.
- Chapter 11 and Appendix B.
- Weekly work due 5.
- Lab practice 2.

Week 8:

- How changing the operating mode leads to substantial changes in small-signal transfer functions.
- Current Programmed Control. Introduction.
- One week midterm exam.
- Student presentation of problem 6.45

Week 9:

- Current Programmed Control.
- Student presentation of problem 6.46
- Lab practice 3.

Week 10:

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Current Programmed Control. Chapter 12 and Appendix B .

- Basic circuit and slope compensation.
- Student presentation of problem 6.48
- Weekly work due 6.

Week 11 :

- Sampled-data modeling of current programmed converters (Supplementary notes).
- Zero Order Hold: Transfer Function.
- Detailed small-signal analysis .
- Simulation .
- Effects of current mode control on basic transfer functions.
- Student presentation of problem 6.49
- Weekly work due 7.

Week 12:

- Current mode control.
- Weekly work due 8.

Week 13:

- Current mode control.

Week 14:

- Four-day take-home exam. Final exam.

5.5.Bibliography and recomended resources

- Erickson, Robert W.. Fundamentals of power electronics / Robert W. Erickson, Dragan Maksimovic . - 2nd ed., 6th

print. New York : Springer, 2004
- Problemas de electrónica de potencia / coordinación y revisión técnica Andrés Barrado Bautista, Antonio Lázaro Blanco . - [Reimp.] Madrid [etc.] : Pearson Educación, D.L. 2012