ECE 5930-002 and ECE 6930-002 – 3 credits

INTRODUCTION TO POWER ELECTRONICS
COURSE SYLLABUS - FALL 2016

Any change in the syllabus will be announced to the students enrolled in the class. Always **check Canvas** for the latest update of the class schedule, reading assignment and homework due dates, etc.

Instructor		Asst. Prof. Zeljko Pantic
Email		zeljko.pantic@usu.edu [1]
Phone		435/797-2457 (Innovation Campus office) 919/593-4052 (Cell Phone)
Office Location	**Main Campus**	EL 304C
	Innovation Campus	USTAR Building 620, UPEL Lab, Office 102
Office Hours	**M/W**	after the class meetings (Main Campus) [2]
	Tu/Th/F	by appointment (Innovation Campus)
TA/grader		TBA

[1] Email is a preferred method of communication. However, consider that email cannot be a substitution for office hour discussion and should be used only to **exchange short and important messages** that cannot wait for lecture time or office hours. Subject box of the email should contain "ECE 5930/6930" text.

[2] **Canvas** will be used as a prevailing method for communication and course material distribution. USU Canvas website is: https://canvas.usu.edu/. To receive all updates in a timely manner, make sure that your Canvas **Notifications Preferences are adjusted properly.**

COURSE DESCRIPTION:

Steady state analysis of dc-dc switching converter, derivation of steady-state models that include losses, efficiency calculation, semiconductor power switches (diode, MOSFET, IGBT), switching loss, discontinuous conduction mode, isolated and non-isolated converter topologies (full- and half-bridge, forward, flyback, Cuk, SEPIC,…) and circuit manipulations, converter dynamics and control, state space averaging and modeling, canonic circuit model, converter transfer function analysis and graphical representation, negative feedback and closed-loop transfer function, controller stability and phase margin, regulator design, review of basic magnetics theory (modeling, loss mechanisms, eddy current), step-by-step procedure of an inductor design.

LEARNING OUTCOMES

1) Understand the basic principles of switching isolated and non-isolated DC-DC converters, learn the technique of steady-state analysis and apply these principles to derive equilibrium conversion ratio of various DC-DC switching converters operating in continuous and discontinues operation modes.
2) Understand steady-state and transient features of contemporary active power switches and power diodes, identify main loss sources in DC-DC switching converters, and conduct an efficiency analysis
3) Develop small signal models of DC-DC switching converters, derive appropriate converter transfer functions and apply them to design linear controllers to regulate selected system variables
4) Learn how to size and select switches and passive components, with the special emphasis on design of practical magnetic inductors
5) Apply computer simulation tools (*Matlab*/*Simulink*) and (*LTSpice* – only 6930) to analyze switching converters and design linear controllers.

COURSE PREREQUISITES

Prerequisites for this course is: **ECE 3410: Microelectronics I (or equivalent)**

To enroll in the course, each student must satisfy prerequisite or obtain a **special permission from the instructor**. Students who do not satisfy prerequisites should **contact ECE Graduate Advisor Mary Lee Anderson** to inquire about the detailed procedure.

COURSE MEETINGS

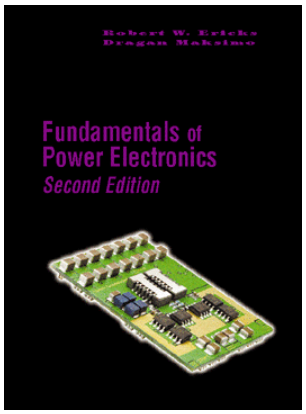
Lectures	Practice Sessions[3]
Days: M/W **Time:** 3:30 pm – 4:45 pm **Location:** EL L109 (W)	**Days:** TBA **Time:** TBA **Location:** TBA

[3] Not mandatory, **but highly recommended**. Practice sessions will be held once per each homework cycle (except for HW1).

COURSE MATERIAL

Textbook (required):

- R. Erickson and D. Maksimovic, "Fundamentals of Power Electronics", Second Edition, second edition, Kluwer Academic Publishers, ISBN 0-7923-7270-0; **Chapters 1-9 and 13-14.**



Book is available through the USU University Library as an **unlimited-user online electronic resource** or for **purchasing** in the University Bookstore. It is the responsibility of the students to access the book material in either way. No special accommodation will be provided for those who cannot do that.

Textbooks (recommended):

- John G. Kassakian, Martin F. Schlecht, George C. Verghese "Principles of power electronics", Addison-Wesley, 1991, First Edition. ISBN: 978-0201096897
- N. Mohan, T. Undeland, W. Robbins "*Power Electronics: Converters, Applications and Design*", Third Edition, Wiley ISBN: 978-0-471-22693-2

Simulation Software:

- **MATLAB/Simulink (student version is sufficient).**
  Students can access Matlab/Simulink through Open Access Computer labs (http://it.usu.edu/labs/lab-software/mat-lab). Be aware that not every computer lab may have installed Matlab/Simulink software package.
- **LTSpice (required only for graduate students)**
  LTSpice is available for a free download from Linear Technology website. Ensure that you have the latest update of the LTSpice.

It is highly recommendable to use available on-line resources at (http://www.mathworks.com/) and (http://www.linear.com/designtools/software/) and get familiar with these two software tools.

GRADING

	Undergraduate Students [%]	Graduate Students [%]
Homework	35	30
Midterm	22	16
Final Exam	28	19
Quizzes	12.5	9
Attendance[(4)]	1	1
Project – interim report	-	8
Project – final report	2.5	18
Σ	101	101

[(4)] Attendance grading policy:

Number of unjustified absences	Grading
>2	0%
0-2	1%

This course uses standard USU letter grading (percentage will always be rounded to two decimal digits):

% max	100.00	92.99	89.99	86.99	82.99	79.99	76.99	72.99	69.99	66.99	62.99	59.99
grade	**A**	**A-**	**B+**	**B**	**B-**	**C+**	**C**	**C-**	**D+**	**D**	**D-**	**F**
% min	93.00	90	87.00	83.00	80.00	77.00	73.00	70.00	67.00	63.00	60	0

Incomplete grade ("I") indicates that a student has up to one year to finish the work and it is NOT common practice "unless extenuating circumstances occur in the life of a student". The university policy on incomplete grades, as well as what might be qualified as extenuating circumstances, is located at http://catalog.usu.edu/content.php?catoid=3&navoid=421#Incomplete

EXPECTATIONS FROM STUDENTS ENROLLED IN 6930 COURSE

Additional expectations from students enrolled in 6930 course include the following:

- Extra problem on homework assignments (Note: not all assignments will have an extra problem for graduate students)
- One or two extra problems on exams
- Class project (Interim and Final reports)

For more details, see the rest of the syllabus below.

HOMEWORK

Homework will be assigned on regular bases in **Canvas**. Students will have at least 7 days for each assignment. To be considered for the maximum number of points, homework solutions must be scanned and submitted as a single pdf document in Canvas by **3:30 pm** of the due date specified. Homework assignment submitted after 3:30 pm, but within next 24 hours will be qualified as a **late submission**.

Late submission policy: Except in a case of documented emergency, for any assignment submitted *N* hours after the deadline, the total number of points will be reduced by 4*N*.

Students are encouraged to discuss HW problems. However, each student must turn in their own homework. Partial credits will be given for partially correct or unfinished solutions, but that will be **applied very restrictively**.

To be considered for the maximum number of points, the solution of problems should be **neatly written**, and embrace all supporting figures and clarifications that are necessary to understand the idea. **Illegible handwriting** will be returned to the student to redo it, and it will be qualified as a late submission. Make sure that you always circle the final solution or underline concluding statement. Each homework assignment submitted must start with a **title page** that provides general information about the student and homework. The title page is provided on Canvas.

Homework for graduate students will typically **contain one problem more than the undergraduate one**. The additional problem is intended to test students' conditional and reflective knowledge through different activities that goes beyond typical textbook problems. It includes: designing components and sub-systems for DC-DC switching converters, the advance application of software tools to design controllers and numerically simulate operation of switching converters, review of power electronics articles, research of some selected power electronics topics, etc.

EXAMS

Midterm (covering material from chapters 1-6) and Final exams will be assigned during the course. The exams will be problem solving oriented. At the exams, the **official course textbook and lecture notes will be allowed**. No other textbooks and problem solutions can be used.

READINGS

Students should **read assigned material before they come to the session**. Material assigned for the readings will be tested through online quizzes that precede each lecture.

QUIZZES

Take-home online time limited quizzes will be assigned to students through Canvas. Each quiz will target a specific part of the course material. **No collaboration is allowed while doing quizzes.**

PROJECT

Project is intended to test student's comprehensive knowledge of power electronics through the design of a regulated dc-dc switching converter that satisfies realistic specifications and considers practical component limitations. Project will include analysis, controller design, component selection, and simulation testing through *LTSpice* and/or *Simulink* simulation tools. Project will be assigned **to graduate students** and more than 1 month will be given the students to finalize the project. Individual project report should be submitted at the end, but students are encouraged to exchange ideas and help each other in resolving practical issues that may appear. Two reports should be submitted during the semester: interim and final report. Each of them will be counted toward the student's final grade.

In order to allow undergraduate students to observe the development of a large power electronics project and to participate to a small extent, undergraduate students will be assigned to graduate teams, as well. Undergraduate students will help to some small extent but mostly, they will observe the design process. They participation will be graded from **0 to 2.5%** based on self-evaluation report, as well as the report provided by their team leader (graduate students). Undergraduate students **do not write the interim either the final report**.

LATE ARRIVAL TO CLASS/EXAMINATION

Try to be punctual and arrive to the classroom on time. If you are late for the class, enter in most quiet manner possible in order not to interrupt your classmates. Student who comes to the classroom **after 3:40** will be allowed to attend the lecture, but will be considered absent toward the attendance policy defined above.

Students who arrive late to the mid/final examination will be permitted to enter and take the exam only if nobody of their classmates has already left the classroom. No time extension will be provided for the late students.

ELECTRONIC DEVICES IN THE CLASS

No electronic devices except non-programmable calculators will be allowed during the exam. **No cell phone verbal communication is** allowed in the classroom. Students **are allowed to use their laptops to take notes**. However, if they decide to do so, they should be seated in the classroom in the **last row** or behind all other students who do not use laptops.

ACADEMIC INTEGRITY

Academic violations of the Academic Integrity Standard include but are not limited to: **cheating, falsification and plagiarism**.

The following text is quoted from the USU Students Code of Conduct:

"Students have a responsibility to promote academic integrity at the University by not participating in or facilitating others' participation in any act of academic dishonesty and by reporting all violations or suspected violations of the Academic Integrity Standard to their instructors. To enhance the learning environment at Utah State University and to develop student academic integrity, each student agrees to the following Honor Pledge: "***I pledge, on my honor, to conduct myself with the foremost level of academic integrity***."

Students are required to be aware and comply with the university policy on academic integrity found in the Code of Student Conduct found at http://www.usu.edu/studentservices/studentcode/article6.cfm

ACCOMMODATIONS

DRC Statement: "Students with ADA-documented physical, sensory, emotional or medical impairments may be eligible for **reasonable accommodations**. Veterans may also be eligible for services. All accommodations are coordinated through the **Disability Resource Center (DRC)** (https://www.usu.edu/drc/) (435)797-0359. Please contact the DRC as early in the semester as possible. Alternate format materials (Braille, large print, digital, or audio) are available with advance notice."

NON-DISCRIMINATION POLICY

The following text is quoted from Student Code of Conduct web page:

http://www.usu.edu/studentservices/studentcode/

"Utah State University is committed to equity in education for its students and that they not be discriminated against/harassed because of **race, color, national origin, religion, sex, age, disability, or veteran status**. In addition, discrimination on the basis of sexual orientation for students in academic programs and activities is prohibited. Student, who feel their rights have been violated, want information, or just need some guidance relating to their course of action relating to Equal Opportunity issues, **should contact the Affirmative Action/Equal Opportunity Office**, located in Old Main, Room 161 or call (435) 797-1266. Information pertaining to other AA/EO-related laws, policies, and issues at the local (USU), state, and federal levels are also available at the office. These items, along with other information, are also available on the AA/EO Office website at: **http://www.usu.edu/aaeo**"