University of Alaska Fairbanks
Electrical and Computer Engineering Department
EE 408 - Power Electronics Design
Spring 2013

Course Information:

Title:	EE 408 Power Electronics Design (3+3)
Lecture Time:	MWF (11:45AM-12:45PM) in Duckering 202
Lab Time:	M (2:15-5:15PM) in Duckering 202, Duckering 330, and Duckering 216
Prerequisites:	COMM F131X or COMM F141X; EE 303; EE 334; EE 354; ENGL F111X; ENGL F211X or ENGL 213X or permission of instructor; senior standing

Instructor: Dr. Richard Wies, Associate Professor, ECE Dept.

Office:	Duckering 213
Office Hours:	W 2-3:30PM, TR 10:30AM-12PM or by phone/e-mail
Phone:	474-7071
E-mail:	rwwiesjr@alaska.edu

Required Text: Mohan, Undeland, and Robbins, Power Electronics: Converters, Applications, and Design, 3rd ed., Wiley, 2003.

References: Daniel W. Hart, Power Electronics, McGraw-Hill, 2011.

Other references provided as needed.

Course Description: Analysis and design of power electronic conversion, control and drive systems with emphasis on smart grid applications. Topics will include the theory and application of thyristors, rectifiers, DC-DC converters, inverters, resonant converters, AC and DC switches and regulators, power supplies, DC drives, and adjustable-speed drives. Includes laboratory exercises using power electronic converter boards and a complete power electronics design project.

Course Goals: Students will develop an understanding of power electronic conversion, control and drive systems with emphasis on analysis and design concepts. The course will develop the building blocks for power electronic devices including rectifiers and converters. Analysis will include the use of PSPICE and the use of Fourier transforms for determining harmonic content. A major design experience will include a project to build an operational power electronic conversion device using knowledge and skills acquired in earlier course work that incorporates "***multiple realistic constraints*** and ***engineering standards***". The ***IEEE code of ethics*** will also be addressed in the design process.

Instruction Methods: Application of fundamental circuit and electronic principles, including time domain and Fourier analysis, in the design, simulation and operation of power electronic devices.

Design Project/Labs: The design project entails working in design teams of two or more designing, simulating, building, and testing a power electronic conversion device using knowledge and skills acquired in previous course work and incorporating "***multiple realistic constraints*** and ***engineering standards***". The ***IEEE code of ethics*** will also be addressed in the design process. The laboratory focuses on the design project with six labs during the first half of the semester addressing concepts and building each stage of a power electronic conversion device. A senior project design requirement and specification handout and a laboratory

<u>Team/Personal Meetings</u>: Each design team will have an interview with the instructor following the proposal and midterm progress presentations to provide

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Student Learning Outcomes:

The B.S.E.E. program at UAF is accredited by the Accreditation Board for Engineering and Technology (ABET). Accreditation requires that all students graduating from this program must achieve the following Program Outcomes. This course addresses the Program Outcomes indicated below in **bold**:

(a) an ability to apply knowledge of mathematics, science, and engineering
(b) an ability to design and conduct experiments, as well as to analyze and interpret data
(c) an ability to design a system, component, or process to meet desired needs
(d) an ability to function on multi-disciplinary teams
(e) an ability to identify, formulate, and solve engineering problems
(f) an understanding of professional and ethical responsibility
(g) an ability to communicate effectively
(h) the broad education necessary to understand the impact of engineering solutions in a global and societal context
(i) a recognition of the need for, and an ability to engage in life-long learning
(j) a knowledge of contemporary issues
(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

EE 408 – Tentative Lecture/Lab Schedule – Spring 2012

All dates and topics are tentative. Exam dates are subject to change.

MONDAY (LECTURE)	MONDAY (LAB)	WEDNESDAY	FRIDAY

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MONDAY (LECTURE)	**MONDAY (LAB)**	**WE[redacted]**	[redacted]
Feb. 13 – Lecture #11 DC-DC Switch Mode Converters: Buck-Boost with CCM & DCM – Section 7.5	**Feb. 13 – Lab** **Lab #2: DC-DC Converters: Buck, Boost, and Buck-Boost** – Sections 7.1-7.5 – **Lab #1 Report Due**	**Feb. 15 – Lecture #12** DC-DC Switch Mode Converters: Cùk – Section 7.6	**Feb. 17 – Lecture #13** DC-DC Switch Mode Converters: Full-Bridge (4-quadrant); Bipolar and Unipolar Switching; Voltage Ripple – Section 7.7
Feb. 20 – Lecture #14 DC-DC Switch Mode Converters: Comparison using Switch Utilization Factor; Equivalent Circuits; Reversing Power Flow – Section 7.8	**Feb. 20 – Lab** Snubber Circuits: Diodes, Transistors, & Thyristors – Sections 27.1-27.9 **Lab #3: Switching Characteristics of MOSFETs & Diodes in DC-DC Converters** – **Lab #2 Report Due** – **Progress Report #2 Due: + IEEE Code of Ethics**	**Feb. 22 – Lecture #15** Switching DC Power Supplies: Intro; Overview – Sections 10.1-10.3 DC-DC Converters with Electrical Isolation: Isolation Transformer Excitation & PWM Control – Sections 10.4.1-10.4.1.4	**Feb. 24 – Lecture #16** Switching DC Power Supplies: Flyback Converters – Section 10.4.2
Feb. 27 – Lecture #17 Switching DC Power Supplies: Forward Converters – Section 10.4.3	**Feb. 27 – Lab** **Lab #4: DC-DC Converters: Flyback and Forward Converters** – Sections 10.4.2-10.4.3 – **Lab #3 Report Due**	**Feb. 29 – Lecture #18** Switching DC Power	

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Mar. 19 – Lecture #22 FET Gate & BJT Base Drive Circuits – Sections 28.1-28.7	**Mar. 19 – Lab** **Oral Presentation II: Midterm Progress Report Presentations** – **Midterm Progress Report Due: Design, Schematic, Standards, Final Parts, Budget, Revised Timeline, IEEE Code of Ethics, Concerns**	**Mar. 21 – Lecture #23** Thermal Considerations for Semiconductor Devices: Heat Transfer and Heat Sink Selection – Sections 29.1-29.4	**Mar. 23 – Lecture #24** Phase-Controlled Rectifiers: Thyristor Circuits – Sections 6.1-6.2
Mar. 26 – Lecture #24 Phase-Controlled Rectifiers: Ideal Single-Phase Converters – Section 6.3.1	**Mar. 26 – Lab** **Lab #6: PWM Control & Driver Circuits in Switching DC Power Supplies: Design, Simulation, Construction, & Testing** – **Lab #5 Report Due** – **Progress Report #4 Due: + Engineering Constraints**	**Mar. 28 – Lecture #25** Phase-Controlled Rectifiers: Single-Phase Converters with Source Inductance – Section 6.3.2	**Mar. 30 – Lecture #26** Phase-Controlled Rectifiers: Practical Single-Phase Converters and Inverter Mode of Operation – Sections 6.3.3-6.3.4
Apr. 2 – Lecture #27 Phase-Controlled Rectifiers: Ideal Three-Phase Converters – Section 6.4.1	**Apr. 2 – Lab** **Design Project Time** – **Lab #6 Report Due**	**Apr. 4 – Lecture #28** Phase-Controlled Rectifiers: Three-Phase Converters with Source Inductance – Section 6.4.2	**Apr. 6 – Lecture #29** Phase-Controlled Rectifiers: Practical Three-Phase Converters and Inverter Mode of Operation – Sections 6.4.3-6.4.4
Apr. 9 – Lecture #30 Switch-Mode Inverters: Basic Concept, PWM, & Square-Wave Switching – Section 8.2	**Apr. 9 – Lab** **Design Project Time** **Draft Project Report Due: Intro, Design, Standards, Constraints, Schematic, PSPICE, Final Parts, Budget, Lab Testing, Revised Timeline, IEEE Code of Ethics, Conclusions (Summary of Current Results, Problems & Possible Solutions)**	**Apr. 11 – Lecture #31** Switch-Mode Inverters: Single-Phase Half-Bridge; Full-Bridge with Bipolar Switching – Sections 8.3.1-8.3.2.1	**Apr. 13 – Lecture #32** Switch-Mode Inverters: Single-Phase Full-Bridge with Unipolar Switching & Square Wave Operation – Sections 8.3.2.2-8.3.2.3

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Apr. 16 – Lecture #33 Switch-Mode Inverters: Single-Phase Full-Bridge with Voltage Cancellation; Switch Utilization; Voltage Output Ripple – Sections 8.3.2.4-8.3.2.6	**Apr. 16 – Lab** **Design Project Time**	**Apr. 18 – Lecture #34** Switch-Mode Inverters: Push-Pull Inverters; Switch Utilization – Sections 8.3.3-8.3.4	**Apr. 20 – EXAM #2** **Cps. 6, 10, & 28-30** **OPEN BOOK** **2 Formulas Sheets**
Apr. 23 – Lecture #35 Switch-Mode Inverters: Three-Phase Inverters and			