Master Course Description for EE-452 (ABET sheet)

Title: Power Electronics Design

Credits: 5

UW Course Catalog Description

Coordinator: Jungwon Choi, Assistant Professor, Electrical and Computer Engineering

Goals: Introduction to the theory, design, and analysis of energy conversion circuits with power electronics. Describe modern applications of power electronics for computing, electric transportation, and renewable energy.

Learning Objectives: At the end of this course, students will be able to:

1. *Understand* the physics and operational principles of power semiconductor devices
2. *Know* the circuit theory which underlies power electronics energy conversion.
3. *Model* the efficiency and input-output behavior electronics circuits with analytical methods.
4. *Simulate* the dynamics of power electronics circuits with software.
5. *Analyze* and design power electronics circuits.
6. *Propose*, formulate, and solve open-ended design problems for power electronics.
7. *Work* in teams with heterogeneous knowledge and skills.
8. *Manage* time in project work.
9. *Write* formal project reports.
10. *Demonstrate* an awareness of current and future applications of power electronics.

Textbook: D. Maksimovic, R. Erickson, *Fundamentals of Power Electronics,* 2nd Ed.

Course Prerequisites: E E 331, E E 351

Course Prerequisites by Topic (PLEASE FILL IN):

1. Analog circuit analysis: Sinusoidal response, KVL/KCL. Phasor, Complex power, Laplace transform, RLC circuit analysis, etc.
2. Energy system basics
3. Electromagnetic Theory
4. Transformer
5. Semiconductor device operation
6. Circuit simulation
7. Filter design and analysis

8. Two-port network

Topics:

1. Introduction and overview
2. Steady-state converter analysis
3. Converter loss modeling
4. Semiconductor switching devices
5. Discontinuous conduction mode
6. Converter circuits
7. Fourier analysis of converter waveforms
8. Transformer isolated converters
9. Converter models and averaging
10. Magnetics design
11. Losses in magnetics

Course Structure: The class meets for lecture three days a week and for lab three hours a week. There is a regular weekly homework and prelab assignments. The lab project also entails one report per student group roughly every three weeks.

Laboratory projects:

1. Power electronics converter simulation.
2. Design and realization of input-side dc-dc boost converter for a battery.
3. Open-ended design project with input- and output-side specifications given.

Computer Resources: Students use software for their homework, laboratory assignments, and lab projects.

ABET Student Outcome Coverage: This course addresses the following outcomes:

H = high relevance, M = medium relevance, L = low relevance to course.

(1) *An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.* **(M)** Power electronics circuitry is described through mathematically sound and physics-based models that are discussed in lectures and used in homework. An example is the necessity to obtain an inductor design which avoids core saturation and meets electrical specifications. The problem is identified through electromagnetic models. The problem is solved via experimental validation.

(2) *An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.* **(M)** Throughout the homework, laboratory experiments, and design work, the students are required to design power electronics systems to meet given objectives under realistic constraints. Designs are tested through numerical simulation or hardware implementation, and modifications are implemented as needed.

(3) *An ability to communicate effectively with a range of audiences.* **(H)** Written reports are prepared for each experiment that comprise the overall design project. A portion of each report grade is based on a verbal competency test to assess oral communication skills. Grades are given for writing quality and oral communication skills.

(4) *An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.* **(M)** The course includes discussion of new and current applications of power electronics, recent trends, and next-generation wide-bandgap devices.

(5) *An ability to function on multi-disciplinary teams whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.* **(M)** Students form teams of up to 3 students in the laboratory and for the design project. A cooperative working relationship is required to achieve the experimental objectives.

(6) *An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.* **(M)** An ability to use the circuit design techniques, hands-on assembly skills, and modern tools necessary for engineering practice. Circuits simulators and oscilloscopes are used as modern tools in laboratory experiments.

(7) *An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.* **(H)** Not all information that is needed to succeed in the laboratory and design project is covered in the lectures. The students have to study data sheets for power electronics devices, consider outside references, and are encouraged to use the Internet to find information in general. This helps students realize that they need to be able to learn material on their own. This mechanism operates strongly during laboratory work.

Prepared by: Jungwon Choi

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