No: E E 458 / E E 533

Title: Power Electronics Controls Credits: 5

UW Course Catalog Description

Coordinator: Jungwon Choi, Assistant Professor, Electrical and Computer Engineering
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Goals: Introduction to the theory, design, and analysis of closed-loop controllers for power electronics circuits.
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Learning Objectives: At the end of this course, students will be able to:

Understand the fundamental concepts of closed-loop control for power converters. Derive the relevant transfer functions of a circuit.

Simulate power electronics with closed-loop controls using software. Design controllers that meet specified performance metrics.

Use feedback and feedforward methods to maximize disturbance rejection.

Propose, formulate, and solve open-ended control design problems for power electronics. Work in teams with heterogeneous knowledge and skills.

Manage time in project work. Write formal project reports.

Demonstrate an awareness of current and future applications of power electronics.
Textbook: R. Erickson, D. Maksimovic, “Fundamentals of Power Electronics,” 2nd Edition
Prerequisites: EE 452; EE 447 (For undergraduates only)

Topics:

Laplace transforms and frequency domain modeling Bode plots

Linear control systems Closed-loop control analysis Current control

Voltage control

Feedforward and disturbance rejection Equivalent circuit models

Analog and digital PWM Current and voltage sensing Analog to digital converters Compensator discretization Digital control systems

Course Structure: The class meets for lecture two days a week and for lab three hours a week. There is a regular weekly homework and prelab assignments.
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Computer Resources: Students use software for their homework, laboratory assignments, and lab project.
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Laboratory Experience:

Power electronics converter simulation.

Programming of digital signal processor (DSP) controllers.

Utilization of hardware-in-the-loop experiments to analyze digital control implementations.

Distinguishing Graduate and Undergraduate Components: Graduate students will be assigned additional homework problems or alternate problems that are more challenging. For lab reports, graduate students will be asked to provide additional supporting analysis and/or simulations for their designs.
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Grading: 25% Homework, 25% Mid-term, 25% Final, 5% Pre-lab Assignments, 20% Lab Reports
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ABET Student Outcome Coverage:

(M) *An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics*. Power electronics circuitry with closed- loop controllers are mathematically modeled using principles of control theory that are discussed in lectures and used in homework. Averaged modeling techniques are used to analyze the plant physics and linearization is applied where appropriate. The output and tracking error are analyzed using closed-loop modeling methods.

(M) *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*. Throughout the homework, laboratory experiments, and design work, the students are required to control systems for converters that meet dynamic performance specifications under realistic constraints. Designs are tested through numerical simulation or hardware implementation, and modifications are implemented as needed.

(H) *An ability to communicate effectively with a range of audiences*. 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.

(M) *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*. The course includes discussion of new

and current applications of power electronics, digital controls, and modern trends in grid and vehicle applications. 5. (M) *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*. 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. (M) *An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions*. An ability to use the control design techniques, hands-on programming skills, and modern tools necessary for engineering practice. Circuits simulators, hardware-in-the-loop, DSP controllers, and oscilloscopes are used as modern tools in laboratory experiments. 7. (H) *An ability to acquire and apply new knowledge as needed, using appropriate learning strategies*. 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.

Religious Accomodation:

Washington state law requires that UW develop a policy for accommodation of student absences or significant hardship due to reasons of faith or conscience, or for organized religious activities. The UW's policy, including more information about how to request an accommodation, is available at Religious Accommodations Policy(https://registrar.washington.edu/staffandfaculty/religious-accommodations-policy/).

Accommodations must be requested within the first two weeks of this course using the Religious Accommodations Request form(https://registrar.washington.edu/students/religious-accommodations-request/).

Prepared By: Brian Johnson Last revised: 9/9/2020