Master Course Description for EE-453 (ABET sheet)

Title: Electric Drives

Credits: 5

UW Course Catalog Description

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

Goals: To introduce students to the design, theory of operation, and analysis of electric drive systems and power electronics with closed-loop control.

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

1. *Understand* the design, analysis, and realization of electric vehicles and drives.
2. *Understand* the operational principles of batteries and motors.
3. *Understand* the basic types of converter circuits.
4. *Design* printed circuit boards for power electronics, sensing, and onboard controls.
5. *Design* converters for electric motors.
6. *Understand* and design various speed controls, braking, and holding techniques for electric motors.
7. *Understand* and design a complete electric drives system for vehicle applications.
8. *Enable* students to carry out and implement a final project on fully-functional battery-powered electric-bike.
9. *Work* in teams to perform laboratory experiments.

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

Reference Texts: Lecture material, web material.

Prerequisites Courses: EE-331, EE-351, EE-452.

Prerequisites by Topic:

1. AC and DC circuits
2. Single-phase and multi-phase analysis
3. Transistors and Diodes
4. Calculus
5. Control systems

Topics:

1. Battery modeling
2. Modeling and characterization of AC machines
3. DC-DC and DC-AC converter analysis and design

4. Loss modeling of power electronics and thermal management
5. Magnetics and transformers
6. Debugging and prototyping techniques
7. Current and voltage control
8. Feedback loop design
9. Layout of power electronics circuits
10. Design of sensing circuitry
11. BLDC control methods
12. Speed torque characteristics of electric drives
13. Digital control coding and implementation

Course Structure: The class meets for two lectures a week, each consisting of 100 minute sessions. A lab session of 3 hours per week is required. There are regular homework assignments and at least one midterm exam. A fully-functional electric bike system must be built by each group by the end of the instruction period. The course concludes with a demo of each electric bike system.

Laboratory projects:

1. Basics of power electronics and electric drives
2. Design of converters
3. Design of printed circuit board layout with power stage, sensing, and digital control components.
4. Design of speed control of electric motors

Computer Resources: Students use computer facilities for their homework and final projects. Simulations of electric drive systems using commercial simulation software is carried out.

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.* **(H)** This course includes mathematical modeling of power electronics, control loops, ac drives, and mechanical loads. The class includes practical engineering problems such as sensing calibration, control coding, circuit debugging, and printed circuit board layout. Students are required to model, simulate, identify, and solve problems in assignments and in laboratory work.

(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.* **(H)** For the laboratory project, students are required to design and build a power electronics drive system for an electric bike that meets given performance requirements and objectives.

(3) *An ability to communicate effectively with a range of audiences.* **(H)** Students are required to prepare a written report on their final projects. The progress of the projects is presented by the students in form of predesign reviews. Grades are given for technical work, writing quality, and oral communication abilities.

(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 impact of electric vehicles, renewable energy, and energy efficiency on infrastructure and society is discussed throughout the course. Students are engaged during the lecture time in discussing and evaluating these issues. Final projects include discussion of the impacts of electrification on the environment and society.

(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.* **(H)** The students may have different backgrounds and strengths, but are cooperatively working to achieve the objectives of the experiments or project. Team members tend to specialize in one aspect of the experiment or project, such as power electronics or embedded digital systems versus machines, creating a multi-disciplinary environment within the team.

(6) *An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.* **(H)** Before the students perform their laboratory experiments, the students analyze the objectives of the experiments and design a setup to achieve these objectives. During and after the experiment, the students interpret their measurements to determine whether the experimental results meet the objectives of the laboratory.

(7) *An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.* **(M)** Not all information that is needed to succeed in the laboratory and design project is covered in the lectures. The course material contains areas where technologies are continually changing. New generations of power electronics devices and machines are continually introduced, and the students understand that they must be capable to track these developments. In addition, students must consult reference sources and inform themselves concerning certain aspects of the course material. This helps students realize that they need to be able to learn material on their own by applying basic and fundamental skills.

Prepared by: Brian Johnson

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