EE 113B/213B: Power Electronics Design

Course Information
Course number: EE 113B/213B (4 units)
Prerequisites: EE 113/213A, or equivalent knowledge
Lecture: Tues 8-9:30am, Cory 540AB
Lab Hours: Thurs 2-8pm, Fri 11-8pm, Cory 125
Website: https://bcourses.berkeley.edu/courses/1542537

Instructor Information
Prof. Jessica Boles (boles@berkeley.edu)
Office hours: Mon 1-2pm, Cory 571
TA Tahmid Mahbub (tahmid@berkeley.edu)
TA Elisa Krause (elisa_krause@berkeley.edu)
TA office hours: Wed 2-4pm, Cory 433

Course Description
Power electronics process electrical energy for many important systems – renewable energy, transportation, manufacturing, computing, consumer electronics, and more. This course is the second in a two-semester series designed to equip students with the skills needed to analyze, design, and prototype power electronic converters. While EE 113/213A provides an overview of power electronics fundamentals and applications, EE 113B/213B focuses on the practical design and hardware implementation of power converters. As such, the primary focus of EE 113B/213B is time in the laboratory, with sequential modules on topics such as power electronic components, PCB layout, closed-loop control, and experimental validation. At the end of the course, students will have designed, prototyped, and validated a power converter from scratch, demonstrating a skillset that is critical for power electronics engineers in research and industry alike.

Course Objectives
By the end of the semester, students having taken EE 113B/213B are expected to be able to:
1. Select commercial components for a power converter design, including switching devices, passive components, PMICs, etc.
2. Populate components onto a printed circuit board, involving soldering of surface-mount components.
3. Design and build power magnetic components.
4. Evaluate and manage thermal dissipation, including with heat sinks.
5. Design gate drive circuits for active switching devices.
6. Program a digital microcontroller to provide open-loop gate signals.
7. Design and implement feedback control of gate signals, including sensing circuitry and implementation on a digital microcontroller.
8. Lay out a printed circuit board for a power converter design.
9. Assemble and operate a power converter test setup, including voltage sources, electronic loads, oscilloscopes, multimeters, etc.
10. Systematically verify the operation of a power converter and troubleshoot unexpected behaviors, including waveform discrepancies and excess power loss.
11. Measure the performance of a power converter in terms of efficiency, temperature, dynamic response, etc.

Course Reference Texts
Recommended: *Principles of Power Electronics* by Kassakian, Perreault, Verghese, and Schlecht, 2nd edition
Optional: *Fundamentals of Power Electronics* by Erikson and Maksimovic, 3rd edition

Tentative Course Schedule

Jan 21-27:	Component Sizing + Soldering + Microcontroller Setup
Jan 28 - Feb 3:	Switches and Simulation
Feb 4-10:	Passive Components
Feb 11-17:	Gate Drive Circuit
Feb 18-24:	Open-Loop Converter Testing
Feb 25 - Mar 3:	Sensing and MPPT
Mar 4-10:	PCB Layout: Footprints + Schematic
Mar 11-17:	PCB Layout: Placement + Routing

Mar 18-23:	PCB Layout: Preparation for Manufacturing
Mar 24-28:	SPRING BREAK (PCBs ordered)
Apr 1-7:	Converter Ramp Up and Testing: Gate Drive Circuit
Apr 8-14:	Converter Ramp Up and Testing: Power Stage
Apr 15-21:	Converter Ramp Up and Testing: MPPT
Apr 22-28:	Converter Performance Evaluation
Apr 29 - May 2:	TBD
May 5-9:	TBD (RRR Week)

Course Format

This course will be categorized into sequential modules focused on different aspects of power converter design and implementation. Each module will contain the following:

1. **Lectures** on module material, as specified in the course information above. Lectures will be held in-person weekly on Tuesdays. Attending lectures is mandatory, and participation in class will be considered when final grades are assigned (e.g., rounding up if borderline). Lectures will be recorded for later reference.
2. A homework-style **pre-lab assignment** intended to familiarize you with the module's topic and have you complete necessary paper calculations prior to lab time. Pre-labs will be due weekly on Thursday at 11:59am (unless otherwise noted), and should be submitted via Gradescope. You are required to submit each module's pre-lab assignment before beginning the lab. Late pre-labs will incur a 10-point penalty (out of 100) per day late, where a day is defined as 24 hours. *Note: If you edit your pre-lab submission after the deadline, Gradescope will automatically update the submission time as the time you edited it.*
3. **Lab time** to complete the module's lab assignment. Staffed lab hours will be held weekly on Thursdays, Fridays, and by appointment with a TA on Mondays, but you are encouraged to complete labs by Friday end-of-day. You will have a reserved block of time in the lab, and you are encouraged to use this time to complete as much of the lab as possible. You are welcome to work on the lab assignment outside of your reserved time if there is space, or outside of staffed lab hours, but you should not count on using the lab when other classes have it reserved: Mon 5-8pm, Tues 5-8pm, Wed 11-5pm, Thurs 8-11am, Fri 8-11am. For Monday lab appointments (for help or check-offs), you must email the TAs with your availability by Saturday at 11:59pm so they have ample time to schedule. You should arrive early to get set up before your appointment begins, and you should be ready to show all check-offs that you seek credit for that day in one appointment. To obtain parts outside of staffed lab hours, email the TAs to schedule a time to meet. *Note: Before beginning Lab N, you must complete Lab N-1 and Pre-lab N.*
4. **Lab check-offs** by course staff, affirming your design has met the lab milestones. Checkoffs will be due weekly on Mondays at 11:59am, and you must complete all lab check-offs for credit (i.e., there is no partial credit for only completing some check-offs). You may complete "late check-offs" during staffed lab hours after this deadline, but late check-offs incur a 10-point penalty (out of 100) per day late, counting only Mondays, Thursdays, and Fridays. The date of your final check-off for each lab will determine your point penalty if late. You are allowed one free late check-off that amounts to one day late without the 10-point penalty.
5. A homework-style **post-lab assignment** intended to have you summarize your results and lessons learned from the lab. Post-labs will be due weekly on Monday at 11:59pm, or at 11:59pm on the day of a late check-off, and should be submitted via Gradescope. To submit a post-lab corresponding to a late check-off, email it to course staff by 11:59pm on the day of your late check-off. Post-labs submitted beyond these deadlines will not be accepted.
6. A **final design manual** intended to have you summarize how to design a power converter, your final power converter design, and your lessons learned from the course.

EE 113B vs. 213B

Throughout the semester, EE 113B students will design their power converters based on a common circuit topology that we will cover extensively in lectures and assignments. EE 213B students will be expected to take the same principles one step further and design their power converters using a different circuit topology of their choice. Accordingly, most post-lab assignments will include extra questions for EE 213B students pertaining to their individual design. The grading format will be the same for EE 113B and 213B.

Lab Etiquette
Please follow proper lab etiquette for ensuring a smooth and organized lab experience for all. Be mindful of only taking parts you need and doing so neatly. Please place the parts bags back in their appropriate bins to avoid losing components or creating unnecessary clutter. Clean up after yourself by properly disposing any waste, returning common tools and cables to where you grabbed them from and returning any unused parts to course staff. If you plan to leave the lab for more than 30 minutes, please clean up your bench so that someone else can use it. During lab hours, no visitors are allowed in our section of the lab.

Ed Discussion Forum
We have created an Ed discussion forum primarily for students to help other students throughout the semester. Course staff will only answer questions on Ed during office hours, if there are no students in attendance (priority for questions during office hours will be the students who attend in-person). Outside of office hours, course staff may be reached via email.

Collaboration
Students are encouraged to collaborate on assignments but must each individually submit their own original work. On Ed, students are encouraged to help answer other students' questions. In the lab, students are encouraged to help other students troubleshoot but must each individually complete their own checkoffs. To incentivize collaboration, we will keep track of students being helpful and consider this when assigning final grades (e.g., rounding up if borderline) and/or writing letters of recommendation in the future. In the lab, the TA will ask if anyone in the class helped you troubleshoot as part of your final check-off for each module (at no cost to your grade), and you should thank those who helped you by providing their name(s). *Note: You should only help other students if they ask for it. Otherwise, you should assume students want to try brainstorming and troubleshooting on their own, which are critical skills to develop. No collaboration is allowed during check-offs.*

Re-grade Requests
Re-grade requests are due one week after an assignment has been graded. Re-grade requests after this period has elapsed will not be reviewed.

Extensions
We will only consider extensions for extenuating circumstances (e.g., a major, unforeseen, *and* provable disruption of academic focus, such as a medical emergency, death in the family, crime incident, etc.). Travel for sports, conferences, university visit days, and other extracurricular activities do not qualify as extenuating circumstances. Extension requests must be made 24 hours before an assignment's submission deadline unless the reason for the extension transpires during this 24-hour period. All extension requests must be made via email to the TAs with instructor cc'd.

Grade Breakdown
Pre-lab assignments: 25%
Lab checkoffs: 40%
Post-lab assignments: 25%
Final design manual: 10%

Grading Scale
A: >90%
A-: >88%
B+: >86%
B: >80%
B-: >78%
C+: >76%
C: >70%
C-: >68%
D+: >66%

D: >60%
D-: >58%
F: <58%

Inclusivity
UC Berkeley values an inclusive environment. All members of this course are expected to contribute to a respectful, welcoming, and inclusive environment for every other member of the course, regardless of background, beliefs, ethnicity, national origin, gender identity, sexual orientation, religious or political affiliation - and other visible and nonvisible differences. If this standard is not being upheld, we invite you to speak with course staff.

Academic Honor Code
UC Berkeley has an Academic Honor Code. As members of the UC Berkeley community, we are committed to acting with honesty, integrity, and respect for others. See more at http://teaching.berkeley.edu/academic-integrity

Special Accommodations and Disability Support Services
If you need disability-related accommodations, have medical information you wish to share, or need any other special arrangements, please let me know as soon as possible. We look forward to working with you to assist you with your approved accommodations.

Mental Health
As a student, you may experience a range of challenges that can interfere with learning, such as strained relationships, increased anxiety, substance use, feeling down, difficulty concentrating and/or lack of motivation. These mental health concerns or stressful events may impact your ability to attend class, concentrate, complete work, take an exam, or participate in daily activities. If you are experiencing such challenges, we encourage you to reach out for support here: https://uhs.berkeley.edu/mental-health
For urgent matters, see this page: https://uhs.berkeley.edu/counseling/urgent