Professor: W. Mack Grady, ENS348, 471-5231, grady@mail.utexas.edu, www.ece.utexas.edu/~grady **Office Hours:** MWF 10-12. Also, he is often in the power lab during the scheduled lab sessions. **Course Web Page:** Linked to <u>http://users.ece.utexas.edu/~grady/</u> under "Course Materials."

Reference Textbook (recommended, but not required): N. Mohan, T. M. Undeland, W. P. Robbins, Power Electronics: Converters, Applications, and Design, Third Edition, John Wiley & Sons, Inc., 2003.

Description: Analysis, design, and operation of power electronic circuits. Emphasis on single-phase power conversion from AC to DC, DC to DC, DC to AC, and maximizing the power from photovoltaics (PV). Design and construction of 150W power electronic circuits in the power laboratory, and comparison of their performance to theory. A working circuit model will be available for observation, study, and improvement. Parts and tools are provided. Use of the ECE machine shop is not required, but those of you who want to use the shop are welcome to do so. But to use the shop, you must first be "machine shop certified." See ECE technicians Paul Landers or Daryl Goodnight about shop certification and use.

Class, Lab Sessions, and Work Schedules:

- Lectures on MWF 2–3, in ENS115.
- Lab sessions in the power lab, ENS212: Sections 16915 and 17275, Thurs. 9:30–12:30; Sections 16920 and 17280, Thurs. 3:30–6:30, Sections 16925 and 17285, Wed. 6:30–9:30pm.
- Always use safety glasses when soldering or drilling.
- Never drill on the lab tables instead, use the drill boxes or black cabinet tops (with a piece of scrap wood between your work and the table top).
- If you solder on the lab tables, keep a piece of scrap wood between your work and the table top.
- The group lab session times shown above are not sufficient to complete your projects. Work with your assigned partner for that project to meet other times as needed during the regular 2nd floor ENS undergraduate teaching lab hours.
- If you have a highly constrained schedule (work hours, sports, Longhorn band, etc.) that will make it difficult to coordinate work times with a partner, or if there are good reasons that you should work by yourself, discuss with Dr. Grady the possibility of being a solo student (i.e., no partner) for the semester.
- Regarding conduct, students should be on-time, and conduct themselves in a manner consistent with a professional environment.
- No cell phones, texting, emailing, web surfing, chit-chat in class. No food or drinks in class or lab.

Prerequisites: EE438 or EE331 with a grade of at least C.

Laboratory Projects: Read the lab document before starting to build! Projects are typically one-week long and require the building and testing of a circuit, and the writing of a report. Projects begin and end during the group lab sessions, according to unique section number. In addition to the group lab sessions, you should plan to work as needed during the regular 2nd floor ENS undergraduate teaching lab hours. For most projects, two-person teams are randomly assigned, with several rotations during the semester. Special requests for partners will be considered but not guaranteed. Solo requests will also be considered. If a section has an odd-number of students, then graduate students may be assigned to solo.

When due, you will turn in your hardcopy report and circuit in team order. Print your names and team number on the top of your circuit. Circuits must be in good working condition. If there is any question about circuit condition, you will be asked to demonstrate your circuit. **Messy circuits will not get credit**.

When new teams are assigned, lockers are usually swapped. The exiting team will present their tools to Dr. Grady and the TAs for checking. Teams are responsible for missing or damaged tools.

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Teamwork: You are expected to work with your assigned partner as a team, splitting the work equally. The parts belong to you both. Do not do the project by yourself, leaving your partner out of the loop, unless you have cleared it with Dr. Grady and have a very good reason. Otherwise, you will receive no credit. For some projects, partner requests will be entertained. Partners must be in the same lab section.

Reports: Each project culminates in a working circuit and a written report. Without a working circuit, there can be no report. Reports (hardcopy only, no electronic) should be single-spaced and no longer than five pages, and stapled at the top left. Both team members receive the same project grade. Sample reports (pdf) are on the web page. Reports and circuits are due at the beginning of lab sessions. You are encouraged to prepare your reports in the IEEE Power and Energy Society two-column technical paper format (see the web page).

Reports are scored with fractional letter grades (e.g., A+, A, A–, etc.). The grading criteria are 1. introduction, 2. description of results (including graphs and waveforms) and any problems encountered, 3. observations, 4. neatness, and 5. conclusions. Explain what you learned in the conclusions. Compare theory to actual results.

Tests and the Final Exam: These cover mostly the theory behind the circuits, and to a lesser extent the lab procedures. You must always show sufficient work to justify your answers. When used, multiple choice questions usually have a provision for "other" answers. Grades for each test and the final exam are typically curved so that each has approximately the same average. There are no makeup tests, but if it works to your advantage, your lowest test (including a missed test) will be replaced with your final exam grade. Please do not ask to reschedule the final exam – the time and date are set university-wide. **Tests from previous semesters are found on the web page. Be smart – study the old tests and practice working out the results throughout the week before a test!**

If you have any questions about the grading of your test, follow this procedure: write down your concerns on a sheet of paper, staple it to your test, highlight on your test with a colored pen as needed to support your case, and return the stapled pack to Dr. Grady within one week.

Laboratory Safety and Equipment: You are expected to take good care of the equipment in the power lab and of the tools with which you are provided. Be a good citizen in the lab, and clean up your messes. Power labs are unlike other labs that you have taken – the voltages are higher. In some cases you will be working with hazardous voltages over 100V. Furthermore, short circuit currents can easily exceed 50A, and significant arcing can occur. Thus, it is important for you to follow the safety procedures explained by Dr. Grady and the TAs. Take off hand jewelry, watches, dangling neckchains, etc. When soldering, use safety glasses! This is especially important when "unsoldering," because when an unsoldered piece pops loose, it can "spashback" hot solder into your eyes. In power labs, you never check out your wiring by simply energizing your circuit and "hoping for the best!" Triple-check your circuit wiring, with your partner, before energizing. Finally, remember to wash your hands after soldering because solder contains lead.

Attendance: Students initial a sign-in sheet at the beginning of each class.

Grading Formula:	Lab circuits and reports	50%
	Three tests	25%
	Note – one 8.5 by 11" sheet of notes is permitted at each test and at the	final exam.
	Comprehensive final exam (during the official U.T. schedule)	15%
	Attendance and lab citizenship	10%

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Group Lab Session Procedure: When a project is due, each team turns in their report (hardcopy only) and circuit when called, in team order. Be prepared to personally demonstrate your circuit to either Dr. Grady or a TA for an "Accept" or "Reject" quality check inspection of performance and construction. If the report is not ready when called, a penalty will be assessed.

Lockers, Locks, and Parts: Our 48 lockers are the only square lockers on 2^{nd} floor. They are on the north corridor. Lockers are assigned as follows: Team #247 gets locker 247, and so on. Combination locks for lockers are randomly assigned each time partners are rotated.

All parts needed for building the circuits are provided. Most hardware, plus common parts such as screws and resistors, are kept in the power lab in the large wooden parts cabinet (southeast corner of the room) and in plastic electronic parts bin. Wire spools are mounted near the large wooden parts cabinet. Other parts are distributed at the beginning of projects.

Each team shares a tool kit (in two plastic ziplock bags, plus a static wrist band for use when handling MOSFETs. See list of tools and photos on following pages. Teams rotate lockers, but tool kits and wrist bands stay in the same lockers for the entire semester. Other tools, such as vises, are found in the power lab. Soldering irons and multimeters are obtained at the checkout counter. Students are given their own pair of safety glasses to keep with them for the entire semester.

TAs:

The main duties of the TAs are to

- 1. Be helpful, have a positive attitude, and treat the students as our customers.
- 2. Assist students by being on duty **in the lab** for approximately 10 hours per week (which includes the weekly lab sessions. (note the first experiment requires more duty hours so that the students get off to a good start).
- 3. Grade the lab reports.
- 4. Practice with the model circuits well in advance to sharpen your proficiency in demonstrating and debugging circuits, and to make sure that you understand the circuits very well.
- 5. Be in charge of the weekly lab sessions, and be prepared to demonstrate the circuits and lab equipment there.
- 6. Help Dr. Grady in keeping track of the parts inventory and wood.
- 7. Help Dr. Grady in making sure that all lab equipment is functional and ready to go.
- 8. Taking apart the circuits and salvaging the reusable parts.
- 9. Prepare the parts bags and wood one week in advance.
- 10. Do you job, do it well, and do it with a smile.

TAs should report for duty 4-5 days before classes start, and remain a few days after the end of classes to complete the end-of-semester tool, equipment, parts, and inventory wrap-up.

Other: U.T. policies regarding students with disabilities will be honored.

Sched	ule:
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Week	Lecture Periods	Lab Periods
Aug. 24	Course overview. Basic circuit	None.
C	components.	
Aug. 29	SCRs, triacs, and light	Assign Light Dimmer and teams. Soldering
C	dimmers.	demonstration and construction tips.
		Oscilloscopes.
Sept. 5 (Mon. is a	Transformers, diode bridge	Light dimmer circuit and report due. Tool
holiday)	rectifiers (DBR). Waveforms	check. Assign DBR and teams.
5,	and definitions.	C
Sept. 12	Photovoltaics and renewable	Review DBR progress. Assign Solar and teams.
1	energy. Test #1 on Friday.	The solar lab does not require lockers.
Sept. 19	MOSFETs and MOSFET firing	DBR circuit and report due. Assign MOSFET
~~~~~	circuits.	firing circuit and teams.
Sept. 26	DC-DC buck converters.	MOSFET Firing Circuit and report due.
		Assign Buck Converter and teams.
Oct. 3	DC-DC boost converters.	Buck Converter circuit and report due.
		Assign Boost Converter and continue with buck
		teams.
Oct. 10	DC-DC buck/boost converters.	Boost Converter circuit and report due.
	PI controller for DC-DC boost	Assign Buck/Boost and teams.
	converter.	6
Oct. 17	H-bridge inverter – basics and	Buck/Boost circuit and report due. Assign PI
	unipolar PWM controller. Test	Controller and continue with buck/boost teams.
	#2 on Friday.	
Oct. 24	H-bridge inverter – basics and	PI Controller circuit and report due.
	unipolar PWM controller, cont.	-
Oct. 31	H-bridge inverters – bridge	Solar report due. Assign PWM Controller
	section and output filtering.	circuit and teams.
Nov. 7	H-bridge inverter – audio	PWM Controller circuit and report due.
	amplifier.	Assign H-Bridge Inverter circuit and continue
		with PWM teams.
Nov. 14	H-bridge inverter – renewable	H-Bridge Circuit and report due. Assign
	power to grid. Test #3 on	Audio Amplifier and continue with H-Bridge
	Friday.	teams.
Nov. 21	Motor drives and other	Thanksgiving week. The only scheduled activity
	applications.	is Monday class.
Nov. 28	Course evaluation.	Audio Amplifier report due. Perform Power to
		Grid experiment. Equipment check-in during the
		usual lab periods.