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A Project-Based Electronics Manufacturing Laboratory Course for Lower-division Engineering Students

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Contents

- Introduction and Teaching Methodology
- Course Outlines and Objectives
- PCB Design Tool Selection
- Sample Student Projects
- Project Evaluation and Assessment
- Summary

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Introduction

- Manufacturing engineering curricula traditionally focus on metal cutting and machining.
- Electronics manufacturing is not traditionally taught in a manufacturing engineering curriculum.
  - Only 3 out of 24 ABET accredited manufacturing engineering programs offered EM courses.
- The $1.3 trillion electronics industry has become a major sector in the manufacturing industry.

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Introduction (Cont.)

- The majority of electrical engineering programs teach basic electronics laboratories using solderless prototyping boards and circuit analysis using simulation software such as PSpice.
- There is a wide gap between prototype design and analysis and the ability to implement an actual electronic device.
- There is a need to have a required lower-division printed circuit board (PCB) design and manufacturing course in engineering education.

Teaching methodology

- Project-based Learning
  - Students are presented with a challenge project, then students decide how to solve the problem in a preset timeline and what activities to pursue.
  - "Learner-Centered," not "Teacher-Centered"
  - Active learning, not passive learning
  - Enhance the compliance with the ABET2000 requirements, 3c, 3d, 3e, and 3g.

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IME157 Electronics Manufacturing

- Introductory course in electronics manufacturing
- Who takes it?
  - Required course for MfgE
  - EE and CPE have a choice of IME157 or IME156 (Basic Electronics Manufacturing)
- Schedule
  - Lecture: twice per week for fifty minutes each
  - Lab: twice per week for three hours each
- Finish two projects in a 10-week quarter
  - A standard continuity tester project
  - A self-selected open-ended project

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IME157 Lab Learning Outcomes

Students will be able to

- identify component (both through-hole and surface mount) types, values, polarity, and orientation.
- use an Electronic Design Automation (EDA) tool to create schematics and layouts of electronic circuits, develop a component library, check design rules, and output manufacturing files.
- choose suitable trace width/space, and pad/hole sizes for both electrical and manufacturability requirements.

IME157 Lab Learning Outcomes (Cont.)

- explain the materials and fabrication processes of printed circuit boards.
- operate various equipments used in PCB fabrication process, and assemble PCBs through manual soldering.
- design a chassis and operate various equipment used in making a chassis for an electronic device.
- exercise project management skills
- exercise communication skills through preparing a proposal, writing a final report, and presenting in class.

IME157 Lab Learning Modules

- Project selection and proposal writing
- PCB Design, Manufacture, and Assembly
- Chassis Design and Fabrication
- Device Testing and Inspection
- Final report and presentation

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Overall Schedules of the Lab Course

Week	Activities	
	Session 1 (3 hours)	Session 2 (3 hours)
1	• Syllabus • Lab safety training • Project discussion	• PCB design tool training • Proposal writing training
2	• Continuity tester chassis fabrication	• Design continuity tester board
3	• Soldering training • 2nd project proposal due	• Manufacture continuity tester board • 2nd project proposal approval
4	• Continuity tester board assembly • Order 2nd project components and kits	• Continuity tester final assembly • Start to design 2nd project board
5	• Continuity tester report due • Students work on their own projects	• Students work on their own projects
6 - 9	• Students work on their own projects	• Students work on their own projects
10	• Final project presentation and report due	

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Comparisons of Various PCB Design Tools

EDA tools		DipTrace		Eagle		PCB123, ExpressPCB PCB Artist	Allegro and OrCAD	PADS or Expedition
Version		Freeware	Non-profit	Freeware	Non-profit			
License cost		Free	$125	Free	$125	Free	$2000 per year	$200 or $500 per year
CAD Limits	# of pin limit	250	1000	No	No	No	No	No
	Board size limit	None	None	100 x 80 mm	160 x 100 mm	No	No	No
	# of layer limit	2	4	2	4	No	No	No
Features	AutoRouting	Yes	Yes	Yes	Yes	Yes		
	Design rule check	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Library	Comprehensive library provided	Yes	Yes	Yes	Yes	Yes		
	Easy to create custom library	Yes	Yes	Yes	Yes	Yes	Require in-depth training	
Ability to export Gerber or ODB++ files		No	Yes	Yes	Yes	No	Yes	Yes
Overall ease of use		Yes	Yes	Yes	Yes	Yes	Require in-depth training	

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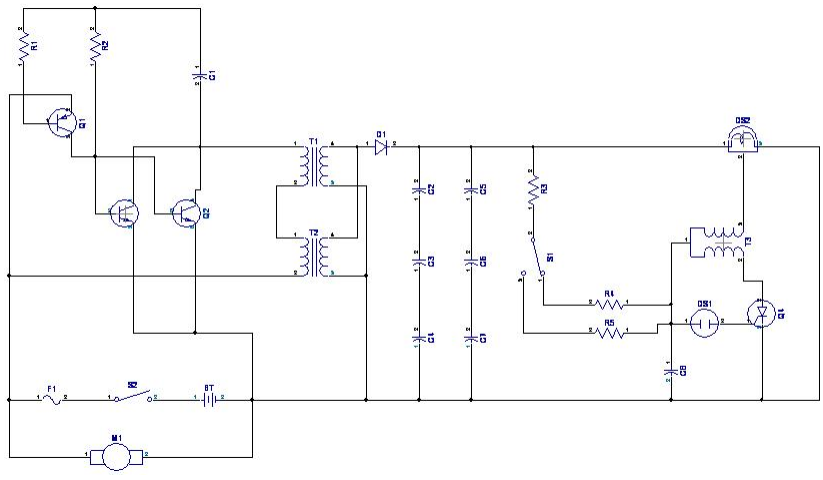
Schematic Sample 1: 12V DC Strobe



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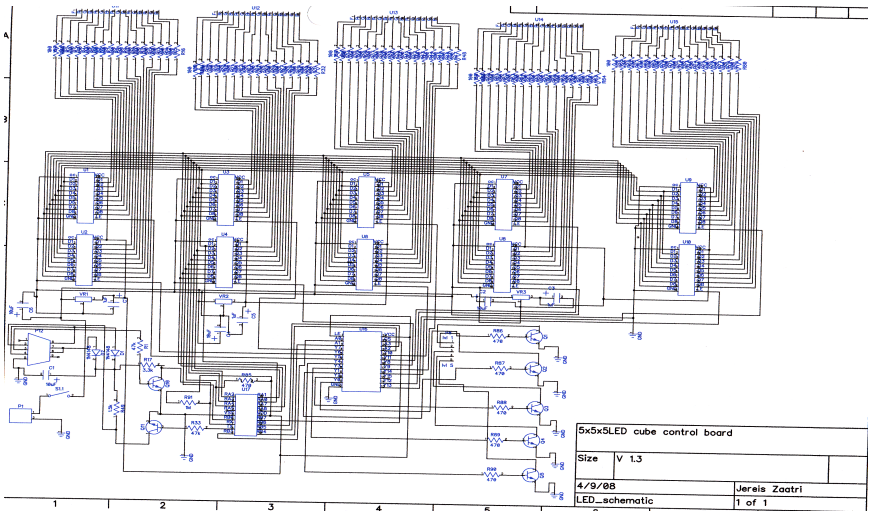
Schematic Sample 2: 5x5x5 LED Cube



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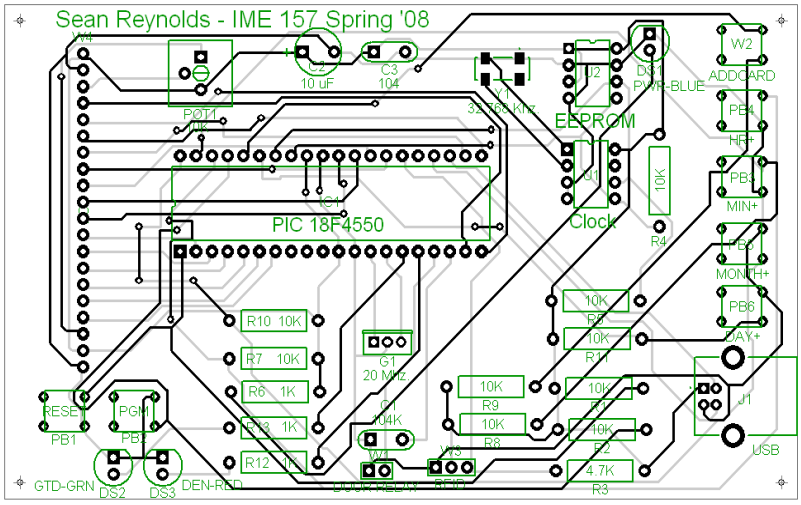
Board Layout Sample 1: RFID Door Lock



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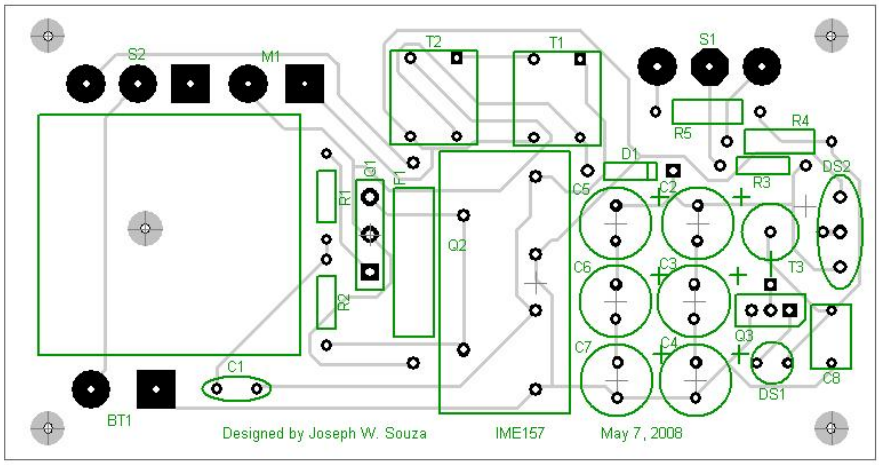
Board layout Sample 2: 12V DC Strobe



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Sample Student Project 1: Power Supply

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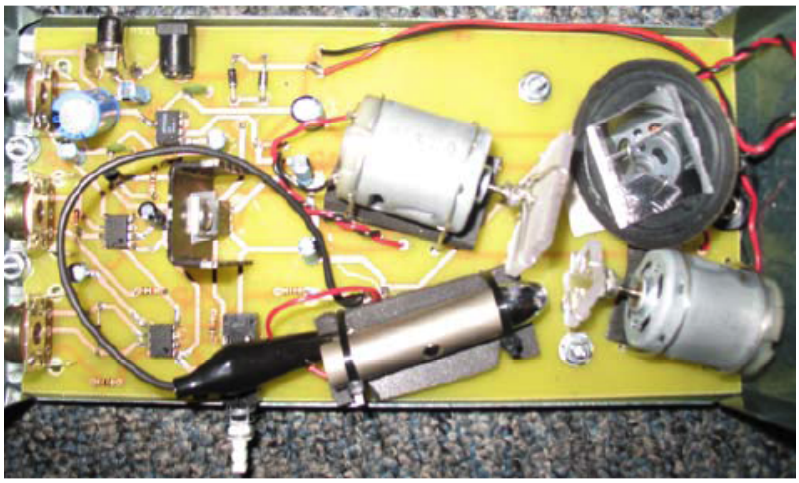
Sample Project 2: Laser Light Show



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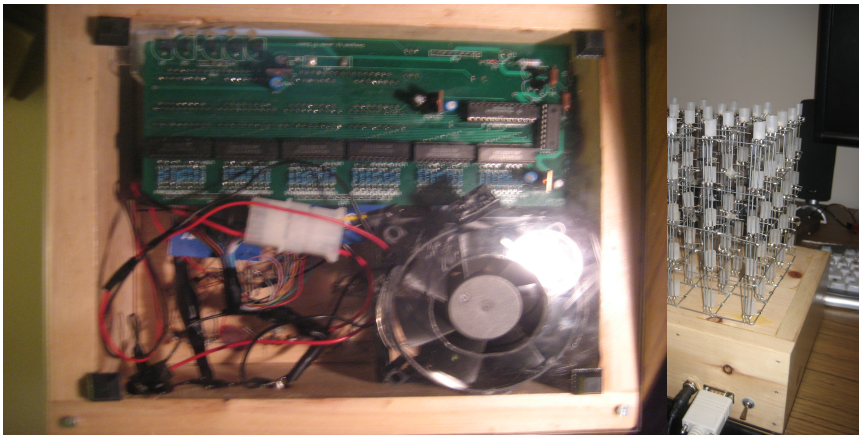
Sample Project 3: 5x5x5 LED Cube



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Project Evaluation

- Students are asked to submit a technical report and give a 10-minute presentation
- Students presentation and projects were evaluated by their classmates and several faculty from different departments.
- Detailed project evaluation rubric was given.

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Project Assessment

- Students feedbacks are very positive.
  - "This is probably the most satisfying project I've ever done."
  - "Overall, this was a very educational experience. … Throughout the project, every aspect of the electronics manufacturing process was new to me, and I feel that I now have intimate knowledge of the art. From soldering, to etching, to board design, I felt that I truly experienced Cal Poly's 'learn by doing' philosophy."
  - "Now I have a better understanding of the advantages and disadvantages of through-hole mounting as opposed to surface mount technology. … the hands-on experience in the lab was very enlightening. Another part of the learning process that I appreciated was the chassis design and fabrication. Being able to construct precision parts out of sheet metal was another key factor that had to be considered in the project design."
- Formal assessment of the project is undergoing.

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Acknowledges

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Thank You!

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Questions?

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Design to Manufacturing Flow Chart for Electronic Products