Experience Learned: Incorporating Industry Supported Project In Power Electronics Course to Improve Learning

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Abstract

One approach to enhance students' learning in practical engineering design issues is to expose students to real world projects using real world components. In introductory power electronics course at Cal Poly, this approach has been implemented through industry's involvement in the final hardware design project. This paper describes experience learned from incorporating this industry sponsored hardware design project. Results to assess this approach through survey conducted by students will be presented.

Introduction

Power electronics is an engineering discipline that deals with the conversion of electrical power from one form to another[1,2]. Power electronics has become increasingly important nowadays where billions of kilo-watts of electric power are being re-processed every day to provide the kind of power needed by loads[3]. At Cal Poly, the growth in power electronics industry has been observed by the increasing number of power electronics companies who came and visited on-campus career fair. This was further accentuated by the growing interest among our electrical engineering students in power electronics. Since 1999, the power electronics courses at Cal Poly have had steady increase in their enrollments[4]. As an example, enrollment in the introductory course EE 410 had grown from 9 students in Fall 1999 to 58 students in Fall 2005.

In the past on-campus career fairs at Cal Poly, power electronics companies were visited to identify their current needs in terms of knowledge and skills that would particularly be of interest for them when hiring new graduates. Several skill-sets and new technical concepts were identified such as those related to multiphase topologies, soft-switching, digital control, surface mount components and soldering, and magnetics. This further contributed to the redesigning of the three existing power electronic courses and to the development of a new course in magnetics design. In addition, new lab experiments in the lab portion of the power electronics courses involving both modern concepts and applications in power electronics have been developed.

To assure that our students possess the skills that are in-line with recent developments in power electronics technology and recent needs by the power electronics industry, a couple of hardware design projects have recently been developed and assigned to students taking the first two power electronics courses. The hardware projects are based on real-world circuit designs and are established in increasing level of difficulty and practicality as students progress through the two courses. One hardware project has received the full support of one power electronics company located in Silicon Valley.

Hardware Project Background

One of the power electronics companies visited during the initial stage of developing the hardware project for the introductory course was the Linear Technology located in Milpitas, California[5]. Discussions during the visit resulted in a plan for a hardware project that was not design-driven, but rather would focus on and would address common issues observed on our recent EE graduates. In particular, Linear Technology has observed that our EE graduates in general lack of knowledge in and of handling the surface mount components. Another practical skill incorporated into this project is the industry standard dc-dc converter performance tests. To help carry out this plan, Linear Technology generously offered to support the hardware project by providing most of the surface mount components and the circuit board required to complete the project.

The Hardware Project

The hardware project for the introductory course was first assigned in Fall 2006 and repeated every Fall quarter when the course is normally offered. Students in the class break into a group of 2 to 3 people to perform the project. The project itself is worth 15% of the overall course grade. Students are given approximately 9 weeks to build and test their circuits. By the end of the 10^{th} week, each group has to perform a live demonstration of their hardware project in front of the course instructor and is being graded based on the criteria defined below:

<u>Project Title: Boost Converter Using LT1615 Switching Regulator</u>

The converter must meet the following specifications:

1. Nominal Input Voltage = 3.3 V
2. Nominal Output Voltage = 20 V
3. Maximum Output Current = 12 mA
4. Peak to peak output voltage ripple at full load of < 1%
5. Load regulation at nominal input 10% to 90% load ≤ 2%
6. Line regulation at full load while input is changed from 2.5 V to 4.2 V ≤ 2%
7. Efficiency at full load ≥ 75%. At the time of the demo, please provide Efficiency Plot with data taken from 10% to 100% of load in steps of 10%.

The grade for this project will be based on:

- How well the converter meets above specifications
- Neatness/aesthetic of the converter (wiring, component placements, layouts)

Upon completion of your demo, you must create a webpage containing:

- Title of the Project and Your names
- A picture of your Boost converter
- A picture of the efficiency plot of your converter

In addition to have a working circuit board, students are required to show to the instructor using industry standard testing equipment, as shown in Figure 1, that their circuits meet all of the design requirements. Failure to meet any one of the requirements will result in a penalty by means of deduction from the total points. Figure 2 shows an example of a completed circuit board from the hardware project.

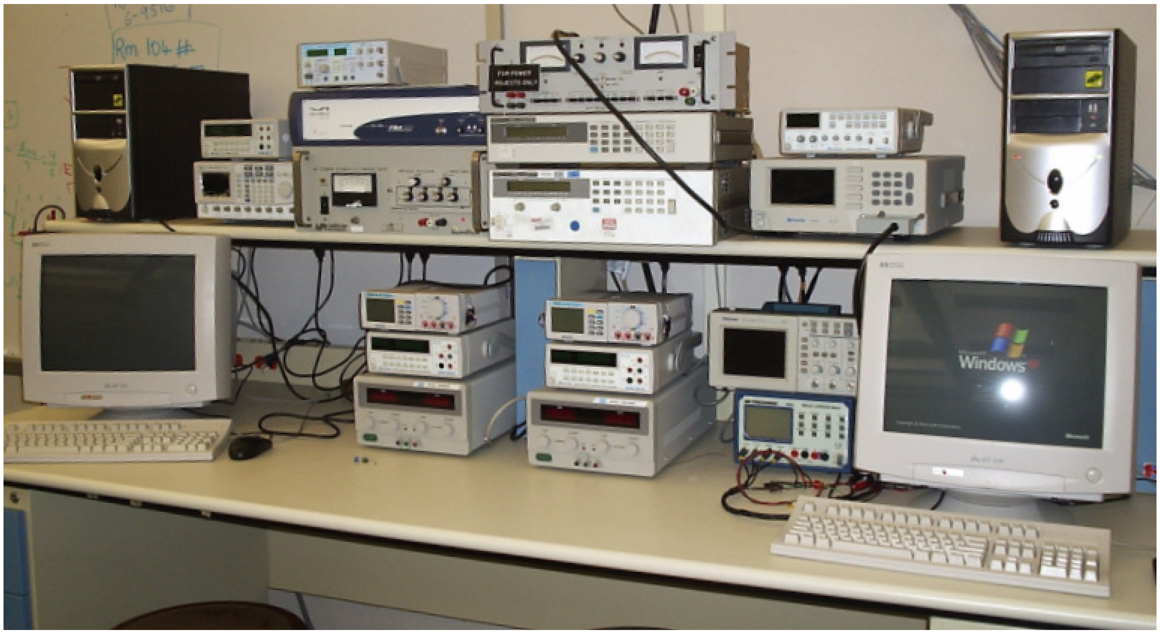

Figure 1. Test equipment used for hardware project demonstration

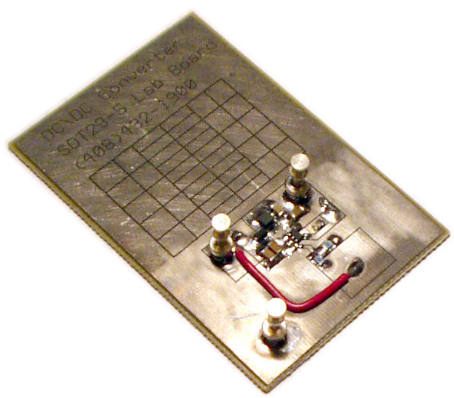

Figure 2. Example of a completed circuit board

Assessment

For the past two years, assessment for the hardware project has been conducted. The assessment was done through survey conducted by students and given at the end of the quarter. At this point, the survey consists of simple Yes or No questions and the survey is aimed to determine whether the project has indeed enhanced students' knowledge in the previously mentioned practical issue, i.e. knowledge of and handling of the surface mount components. The survey is typically given to students at the beginning of their final exam time. Results of the survey were then shared with the sponsoring company for further discussions and feedbacks.

Table 1 shows the seven survey questions and the responses from students. The data shown are the results averaged over the past two years.

Table 1. Survey questions with responses

Survey Questions	**Yes**	**No**
Before this project, have you worked on surface mount components (selecting, buying, or soldering)?	25.15%	74.85%
Before this project, were you aware of surface mount inductor?	44.40%	55.60%
Before this project, were you aware of surface mount power electronic components?	49%	51%
Has the project increased your awareness of surface mount power electronic components?	98.11%	1.89%
Has the project increased your skill in working with surface mount components?	98.74%	1.26%
Has the project helped you in learning dc-dc converter in general?	95.29%	4.71%
Has the project helped you in learning dc-dc converter performance testing such as line and load regulations, efficiency, and peak to peak output voltage ripple?	91.36%	8.64%

Looking at Table 1, we can conclude that the project overall provides positive learning experience for students. Students feel that the hardware project has improved their awareness and skill associated with surface components. For the broader aspect of understanding dc-dc converter and its standard testing, data from the survey also show that more than 90% of the class feels that the hardware project has helped them in this aspect.

Feedbacks from students were also obtained verbally through conversations during the circuit design and build process. Some difficulties encountered from student's point of view include the steep learning curve on soldering and handling tiny surface mount components which was found to be time consuming and frustrating. In addition, due to the time constraints the project has minimal exposure on the component selection aspect of the design. Students often mentioned that the hardware project made them learn and understand practical issues such as layout and minimizing capacitor losses from equivalent series resistance (ESR). From the instructor's perspective, a lot of time has to be allocated to help students troubleshoot problems and to be present during their hardware demos.

One significant outcome of this hardware project through personal observation is that the project seems to prepare students more technically when coming to the next power electronics class. The author found that students are more confident and more skilled when conducting the second hardware project which is a technically much more challenging hardware project.

Conclusions and Further Work

In this paper, a new industry sponsored hardware project assigned to an introductory power electronic course has been presented. The project aims to expose students of practical issues in power electronics design which in turn enhances their learning as evidenced by the results of the survey. Based on the survey done by the students, the hardware project has indeed helped them to be more aware and skilled in dealing with surface mount components and dc-dc converter industry standard testing procedures. Students seem to be more prepared and confident as well when taking the more advanced power electronics course with a much more challenging hardware project. Much work still needs to be done in terms of improving the survey questions to assess the level of skills and knowledge before and after the hardware project. In addition, several more survey questions should be added to assess other knowledge and skills beyond those related to surface mount components. Equally important is that Linear Technology as the industry expert and counterpart on this effort should be involved in the assessment process. Do they or other power electronics companies feel that our EE graduates now are more knowledgeable and skilled when it comes to surface mount components? Do they or other power electronics companies feel that the hardware project has enough coverage addressing their initial concerns? These are examples of follow up questions that will be very useful to know to continuously improve the content of the hardware project.

Bibliography

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