Using Senior Research, Design, and Development Projects in the Development of a Course in Electric Vehicle Technology

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Abstract:
This paper details an approach that we used in the development of laboratory experiments, course materials, and laboratory facilities for a course in electric vehicle technology. In particular, we describe how students assisted us in the development of the course by conducting research and design projects, in the semesters prior to the first offering of the course. We will describe the mechanism for assigning credit for such work in our department, how advising of students on such projects is carried out, the typical kinds of projects that students conducted, the results of the work done by the students, and their responses to the experiences. We will also describe the electric vehicle course that was the focal point of the student projects, the problems that students had to overcome in order to complete their projects, and the success of this strategy for developing an elective course in an emerging area.

I. Introduction

In order to develop a course, general guidelines can be followed. This may start with a new idea that meet certain educational objectives and professional activities for job career. An engineering course that combines theory and design, practice with hands-on experiences, industry collaboration, and teamwork across disciplines may require a development plan with a team of faculty from across majors with different specialties. The implementation plan of such a course can be developed to meet the course objectives. Unlike developing a course in common and popular engineering areas where plenty of textbooks are available to assist in the development, an industrial-based course in a new area may require heavy industrial collaboration in developing lecture notes and laboratory components from technical manuals and technical journals.

The area of electric vehicle technology is new to engineering and technology education. There are few courses developed across the country with varying objectives. Our course was designed to achieve the following: integration of knowledge from normally unrelated topics that are usually covered in several different courses, industrial cooperation, hands-on experiences, preparation of students for a career in the automotive sector, and to enhance student ability to work with students from different majors. This course is different from other elective courses in traditional EE or EET curricula. Unlike any elective courses, where theory is covered first and applications are used to support the theory, the emphasis of this new course is an application (electric vehicles in this case) while different theories are covered to support this application.

II. Approach

2.1 Why the Electric Vehicle Platform was Selected for EE and EET Majors?

In order to incorporate un-related areas such as digital signal processing (DSP), electromagnetics, energies and batteries, power electronics, fuzzy logic, and solid state devices, the electric vehicle platform was selected. Because of the common interests between EE and EET students related to these topics, we emphasized technical aspects of the course to be electronics fundamentals of this application. In addition to being suitable for integrating the knowledge, the timeliness of this application is important to prepare engineers and technologists for the EV and HEV industry.

2.2 Course Topics

As shown in the block diagram in figure 1, the electronic fundamentals of the electric vehicles consist of power electronics of the inverter, where the solid state devices (IGBT) and pulse-width modulation (PWM) circuitries reside, the three-phase motor, a battery system, and a data acquisition system. There are two versions of EV1 propulsion system: a motor with a controller and without a controller. In the latter, Texas Instruments (TI) DSP controller is utilized to control the system. Details of these topics and the problem associated with the design have been presented elsewhere [1-3].

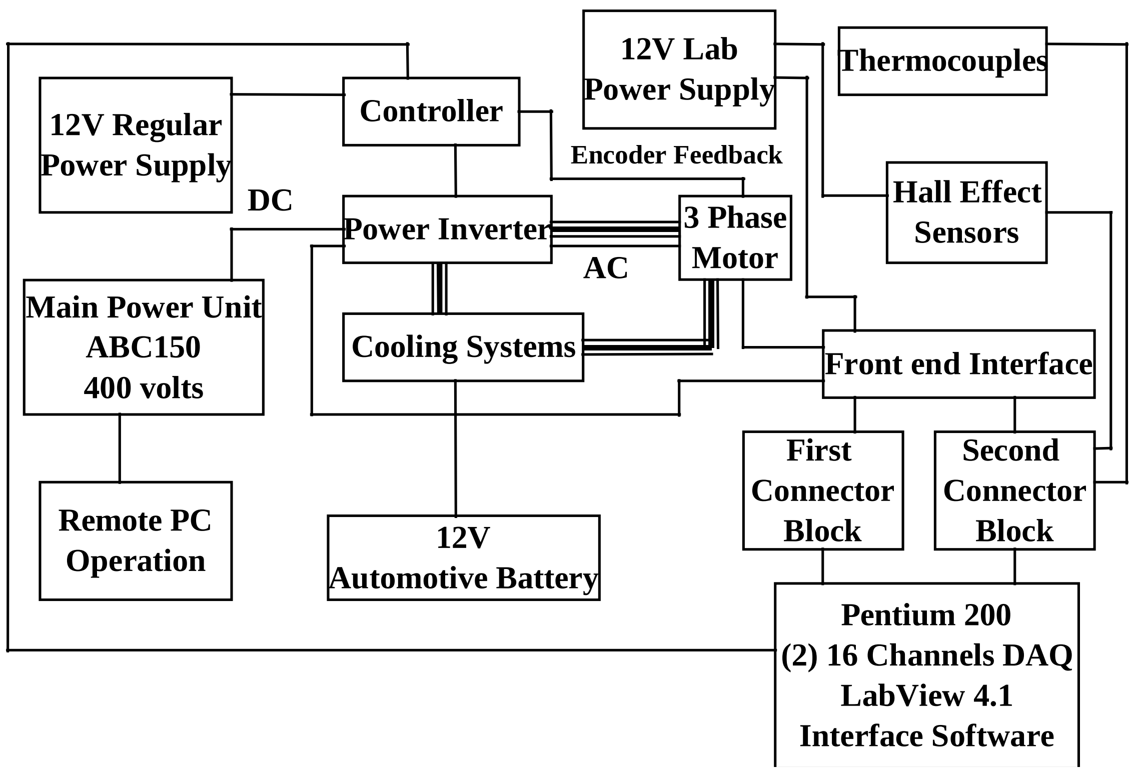

Figure 1: Block Diagram of the EV

2.3 Research, Honor, and Senior Design Courses Used in the Development

At the Purdue School of Engineering and Technology, IUPUI, students can use several options to conduct individual research and design projects.

The following courses were used:
1. H399 (3 cr. Hrs.): Honor Course
2. EE492 (3 cr. Hr.): Senior Design Capstone
3. EE491 (1 to 3 cr. Hrs): Senior Design Project
4. EE496 (1 to 3 cr. Hrs.): Senior Project

Because of the confidential information regarding the donated propulsion system, we did not access to the manual and documentation for the engine. A student conducted an honors project to develop course material regarding the generic circuitries of the propulsion system. Reverse engineering was used to get power electronics control circuit for the propulsion system. Students taking this course must have good software and laboratory skills to understand the concept and learn means of approaching the solution. Starting with a generic high power circuitries, students were able to obtain a satisfactory response (in comparison with the industry response provided by GM) through reverse engineering. Students used PSpice simulation with devices provided in its library to obtain a comparable results with those provided by GM.

The DSP part of the course was covered by the EET faculty member. The laboratory component of this section utilized TI DSP microcontrollers to control three phase-motor for a given acceleration and speed. EET students worked on individual senior design projects under EET faculty supervision to implement four experimental laboratories that cover the use of the TI microcontroller and its application to EV propulsion systems. In order to provide student safety in this course, we decided to use LabView data acquisition system so that student can access to the propulsion system through a PC. Twenty-four channels were installed to access to high currents, voltages, PWM, and temperatures in different locations in the propulsion system. Because this is a big project, it required a team of students to install hardware and write the software, and validate results of the currents and voltages with the theoretical obtained performance. For this purpose, EE492 (3 cr. hrs) was assigned to a team of 5 students who were able to learn under industry and faculty supervision to implement data acquisition system for the GM EV1 propulsion system.

Throughout the development of the course, we needed to understand data acquisition for a battery charging system (ABC150) where students can write script files to safely monitor the maximum voltages, currents, and power entering the system. Five students were assigned to do their projects using our EE496 senior project format, which allows students to develop instructional materials to be used in classroom. Five students were given summer courses to develop instructional materials for the ABC150 data acquisition and verify their script files to be used for auto mode operation.

LabView software was found to be an integral part of the course be able to monitor important parameters in the high power propulsion system. Therefore, two more students were assigned an EE496 project to develop a CD-ROM that contained instructional material that gave detailed instructions on how to use LabView in EV applications. This CD-ROM is currently used in the course to assist students in learning to use the tools.

EE491: variable credit design course are given to students who want to do individual design courses such as computer simulation for a propulsion system to model three-phase motor with IGBT control circuits. The PWM circuits were designed using op-amp comparator circuits.

III. Assessment:

Table 1 and 2 present the feedback from students who participated in the development of the course and from industry.

Table 1. Assessment of Student Satisfaction of EE Project Students

	Item	Results (n = 4)
1	In my project course, I learned technical contents that were not covered in any other EE courses.	4.75
2	I enjoyed using computer simulation software to model electric Vehicle components.	4.62
3	I enjoyed using LabView to develop data acquisition system.	4.75
4	I enjoyed the hands-on aspects of my project	4.60
5	Courses like this motivate me to put more efforts into my studies.	4.60
6	I enjoyed learning about the operation of the different components of the vehicle.	4.75
7	If I were looking for more technical electives, I would like to continue taking more credits in this area.	4.60
8	I am interested in working on a senior design project in this area.	4.90
9	I enjoyed doing outside reading and research to learn more about the different component systems in the electric vehicle.	4.25
10	I enjoy learning on my own with guidance from the instructor.	4.88
11	This course required me to integrate knowledge from other courses that I have taken.	4.88
12	I would like to find a job in this area.	4.38
13	The materials covered in this course have given me a better view of how my engineering education is preparing me for work in industry.	4.50
14	Overall, taking this course was an enjoyable experience.	4.75

Table II: Feedback from Industry

Item	Industry
1. Appropriateness and quality of the laboratory equipment in the Propulsion Laboratory of the School.	5.0
2. Appropriateness and quality of projects in the course.	5.0
3. Satisfaction with engagement with students of their field trip to Allison Transmission, Inc.	4.0
4. Satisfaction with student interaction during guest lectures on "Hybrid Materials for Trucks and Buses"	4.0
5. Appropriateness and quality of course materials.	5.0
6. Ability of the course to prepare students for jobs in the electric vehicle sector.	4.0

7. Appropriateness of the design methods to prepare students for careers in design in the electric vehicle sector.	4.0
8. Value of integrating engineering and technology students in a senior elective course.	5.0

IV. Discussions and Conclusion

As it can be seen from the above two tables, students were excited by their experiences in the projects they conducted, from the hands-on experiences, and the chance to integrate knowledge from different technologies. Industry representatives have also have seen this course to be exciting, motivating, and important towards preparing students in the EV and HEV career.

References

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