

A Multidisciplinary Design Project in Energy Conversion Electromagnetics Course

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ABSTRACT

This paper presents a work-in-progress on a new multidisciplinary design project for an Energy Conversion Electromagnetics course at Cal Poly State University. The project is intended to strengthen the skills of electrical and mechanical engineering students by performing design tasks in a multidisciplinary environment. Concurrently, this new design project is implemented to fulfill ABET criterion 3d. The content and format of the project will be described in this paper. Assessments planned for the project will also be discussed.

Categories and Subject Descriptors

A.1 [Introductory and Survey]:

General Terms

Design, Performance, Measurement

Keywords

Multidisciplinary, design project

1. INTRODUCTION

ABET criterion 3d for engineering program calls for “an ability to function on multi-disciplinary teams” [1]. To satisfy this criterion, the Electrical Engineering program at Cal Poly State University has recently initiated the Multidisciplinary Certification as part of the graduation requirement. In particular, the following new paragraph was inserted into the upcoming 2007–2009 catalog [2]:

The Electrical Engineering program requires students to be “Multidisciplinary Certified” for graduation. This provides students an opportunity to

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practice skills associated with working on multidisciplinary teams. Such experience is important for practicing engineers, with the ever-increasing diversity of engineering science and applications. For Electrical Engineering majors, this requirement is satisfied by taking a required course, EE 255. Visit the Electrical Engineering web site for more information. Also see further discussion in the catalog under College of Engineering.

Hence, beginning academic year 2007, every electrical engineering (EE) student must fulfill the multidisciplinary certification requirement. This requirement is met by every EE student after completing the required EE 255 course entitled Energy Conversion Electromagnetics. Presently, EE 255 is a 3 quarter unit course required for electrical and mechanical engineering majors. The course has lab component which is a 1 quarter unit co-requisite laboratory course called EE 295.

Presently, both EE 255 and EE 295 are required for mechanical and electrical engineering students. However it was then decided that the multidisciplinary project should be assigned in EE 225 course. The reasons are two-fold:

- EE 255 has more students than EE 295. Typical enrollment for EE 255 is 32-36 students per section whereas enrollment in EE 295 is 15-18 students per section. The larger number of students in EE 255 makes it easier to form groups with a good mixed of mechanical and electrical engineering students.
- The new project is geared more toward theory and is therefore more suitable to assign in the lecture course.

Under ABET criterion 3d, the electrical engineering department at Cal Poly has defined the following set of skills:

1. Recognize value of a multidisciplinary team.
2. Communicate effectively with colleagues in other disciplines and listen well.
3. Employ flexible styles and behaviors and recognize the style of another.
4. Identify when problems occur due to poor team member interaction. Identify ways to improve team dynamics.

To ensure that every EE student learns each of the above skills, the new multidisciplinary project must comprise of and blend electrical and mechanical components. Also, having both components in the design problem will in turn require students from both majors to work independently as well as collaboratively for the successful completion of the project.

2. THE DESIGN PROJECT

The new multidisciplinary design project has the following objectives:

- Should integrate most of the topics in EE 255 course.
- Should generate interactions within each group between electrical and mechanical engineering students.
- Should expose electrical engineering students to mechanical side of the electromechanical systems and mechanical engineering students to a more electrically design oriented project.

The first version of the new multidisciplinary project had been completed and was then assigned at the beginning of winter 2007 quarter to two sections of EE 255. The following illustrates the content of the first version of the project:

The owner of a small farm in Los Osos uses a well to irrigate his crops. The well is about 75 feet deep. A one-hour irrigation period at a flow rate of 150 gallons per minute is required everyday. Your group is to determine the following:

- The size of the pump (in hp) needed to irrigate the farm.
- The size of the three-phase induction motor needed to operate the pump. Assume a voltage source of 240 V and 60 Hz. The motor has six poles. The power factor (pf) of these machines is in the range of 0.75 to 0.8 lagging.
- The size of the capacitors needed to correct the power factor to unity. Assume y-connected capacitors.
- The KVA ratings per phase and the three-phase connections of the three single-phase transformers needed to feed the induction motor. The efficiency of each transformer ranges from 90% to 95%.
- The number of turns of the primary and secondary windings of the transformer per phase assuming a maximum core flux of 5mWb and a nominal high voltage side line-to-line voltage of 4160 V.
- The dimensions of the magnetic core for a 5mWb flux using the magnetization curve shown. Assume a square cross-sectional area and a magnetizing current of 5% of the rated current.
- Sketch the core of the magnetic circuit showing all the dimensions. Assume core-type magnetic circuit.

- The overall efficiency of the system. Assume the line impedance between the transformer and the motor is $0.05 + j0.15\Omega$ and the impedance between the source and the transformer is $2.5 + j10\Omega$ for the following induction motor power factors:
 - Selected power factor and Unity power factor.
- The cost (in dollars) of the electrical energy consumed in 30 days assuming 18 cents per KWH for the following induction motor power factors:
 - Selected power factor and Unity power factor.
 - The savings (in \$) gained by improving the power factor to unity.

The design project was assigned as a group project consisting of 3–5 students per group. Each group will be required to turn in a group report by the end of the quarter. Presently, the project is worth 10% of the total grade and will be graded based on the following criteria:

- Accuracy of the results.
- Engineering assumptions used in obtaining the solution.
- Cooperation among members of the group.
- Organization and neatness of the report.

3. ASSESSMENT

Assessment questions for the multidisciplinary project are currently being developed. Papers [3, 5, 6, 7, 8] discussed assessments of teamwork and individual's contributions to their team. However, they lacked addressing student perceptions of interdisciplinary interaction. Paper [4] in particular discussed survey instruments that addressed individual's contributions to teamwork and interdisciplinary interaction of the team members. With respect to the new multidisciplinary project, it would be beneficial for the EE program at Cal Poly to know at least the following:

- How well the EE program is in providing every EE student with the ability to work with a team of persons from other disciplines to achieve a common goal function on multi-disciplinary teams.
- How well EE students achieve skills in multi disciplinary teamwork and communication. How well EE students accomplish the skills defined under criterion 3d for EE.
- How well EE students are in their ability to be an effective contributing member on multi-disciplinary teams, to manage projects, and to communicate effectively in oral and written forms.

More specific survey questions that will be given to students as part of their final exam are currently being developed. To follow are some examples:

- Identify a project activity that could not have been accomplished as easily working alone versus on the team.

- Describe a situation where communication was challenging.
- Describe a situation where listening well was important.
- Describe a situation where a team member was persuasive.
- Describe how a team member's style of working differed from your own and how this was accommodated.
- Provide some constructive feedback that might help improve another team member's skills.
- How did your project suffer due to poor team dynamics?
- What underlying issues affected team dynamics on your project?

4. CONCLUSIONS

In this paper, a new multidisciplinary design project for the energy conversion electromagnetics course has been presented. The project was introduced to satisfy ABET 3d criterion and was assigned to two sections of EE 255 in winter quarter 2007. This is work in progress, hence assessments are currently underway and results as well as lessons learned from the project will be presented in future papers.

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