

ELEG 488V – SPECIAL PROBLEMS: A MEANS TO IMPLEMENT UNDERGRADUATE RESEARCH

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ABSTRACT – The paper describes a more intensive use of ELEG 488V – Special Problems, a senior-elective course, as a mean to implement (undergraduate) research when a faculty member faces the dilemma of performing research work with dwindling research budgets, satisfying companies having close ties to the University with small projects with no budget, and also preparing those undergraduate students interested in power engineering to perform independent work or even pursue graduate studies. The projects addressed by the students are closely associated with “real-world” problems; in fact, most problems come from industry. In this manner, the bridge between the university “theoretical” world and the industrial “real” world are brought a little closer. This methodology is proving very beneficial to both the undergraduate students and this faculty member as explained in the paper.

I. INTRODUCTION

In general, university faculty are having difficulties in (1) attracting sufficient research dollars from industry and/or government due to different varying reasons, and (2) satisfying research sponsors with limited research dollars. Thus, it is becoming more difficult to perform research work in two or more related topics. At the same time, industry is placing more requirements upon engineering graduates in order to face the new challenges imposed by a very competitive (world) market. One of these requirements is that engineering graduates should carry out relevant projects in an independent manner within a short period of time after their graduation dates. The “over-crowding” and “down-sizing” of the engineering curriculums are making it difficult to teach the skills required to successfully carry out projects independently. At most engineering departments, the learning of these required skills normally takes place in a senior capstone design course.

This paper focuses on the efforts by this faculty member from the Department of Electrical Engineering (EE) at the University of Arkansas in Fayetteville to develop “hands-on” laboratory experiments and/or perform research work while allowing some undergraduate students interested in the power engineering area to gain knowledge on a power topic not offered in our power courses and acquire the skills to carry out a project in an independent manner. This is done through ELEG 488V – Special Problems, a senior-elective variable-credit course, whose catalog description states that it consists of individual study and research on a topic mutually agreeable to the student and a faculty member.

Although most engineering colleges have this type of course in their curriculums, the use of this course as a viable alternative to other technical senior elective courses is not strongly emphasized by faculty members. Furthermore, this course complements the objectives of the senior capstone design course while providing similar information to a technical senior-elective course. The paper describes five projects performed under the above course title as examples: namely,

- (1) an ultrasonic welder,
- (2) a finite-element analysis (FEA) of a switched reluctance motor,
- (3) voltage surges on electric motor terminals when supplied from a Pulsewidth Modulated (PWM) inverter through long leads,
- (4) a microprocessor-controlled induction motor drive, and
- (5) an analysis of the noise produced by induction motors supplied by PWM inverters.

Finally, this paper presents the advantages for the students and the faculty member.

II. SEARCHING FOR UNDERGRADUATE STUDENTS IN POWER ENGINEERING

The lack of job opportunities in power engineering over the past few years has led to fewer students taking power courses. In some cases, this has resulted in offering fewer power courses, and in other cases, the power program was closed down due to poor student interest and budget restrictions when power faculty retired. Among the reasons for fewer jobs in power engineering, the most important ones are:

- (a) Electric utilities are in general not hiring engineers since they are busy re-structuring (down-sizing) in order to be competitive when the deregulation of the utility industry takes place in the near future.
- (b) Other “power” industries (e.g., motor-drive manufacturers) are also down-sizing and tend to hire experienced engineers or recent graduates having a broad-based background in power engineering (e.g., power, power electronics, microprocessors, etc.). This broad-based power background can be only obtained at a few tier-1 universities.

On the other hand, companies with close ties to the University are coming with real-world power-related “special projects” without a budget but with a real need within the company. Undergraduate research provides a means to satisfy these companies. However, it is hard to find undergraduate students (or even potential graduate students) having the required background in power engineering due to the above mentioned reasons. At this point, it could be added that, in general, undergraduate students are not prepared to perform independent work due to the “spoon-fed” approach followed in most courses. In other words, students are being prepared more to follow “cookbook” instructions and regurgitate information rather than to perform analytical or critical thinking (this has been the subject addressed by several papers).

Faced with preparing students to perform research in power engineering and satisfying industry needs, this faculty member decided to make a more intensive use of ELEG 488V – Special Problems.

It must be noted that ELEG 588V – Special Problems (which provides the same opportunity for graduate students) is heavily used by our graduate students due to the limited amount of graduate courses offered in a particular area in our small EE Department.

At the beginning, a senior student wanted to carry out a Special Problem since he had an interest in power and the offered technical electives were not of his interests in a particular semester. Word of mouth then helped to recruit more undergraduate students for other power projects. Today, the undergraduate program coordinator posts also on department bulletin boards the different ELEG 488V – Special Problems offered by the EE faculty.

III. EXAMPLES OF SPECIAL PROBLEMS

A brief description of the most recent Special Problems follows.

(1) An Ultrasonic Welder

The objective of this project was to simulate and implement an H-bridge converter to produce a 40-kHz voltage output for an ultrasonic welder. The power MOSFETs of the H bridge had to switch at 400 kHz. The undergraduate student learned how to simulate power electronics based circuits using PSpice and gained very valuable insight into building prototypes. In other words, he gained valuable design experience which complemented his senior capstone design project.

(2) A Finite-Element Analysis of a Switched Reluctance Motor (SRM)

This Special Problem consisted of analyzing a three-phase SRM having six stator poles and four rotor poles. The first task of the undergraduate student was learning FEA and ANSYS, a finite-element computer package. As course topics, FEA and ANSYS are taught in the Mechanical Engineering (ME) Department; therefore, the help of the ME faculty member teaching the corresponding class was enlisted for this project. FEA is an important technique used in different engineering disciplines for design purposes. The final project objectives were to calculate: (a) the fluxes in the different sections of the SRM, (b) the torque curve, and (c) the different inductances of the SRM for different positions of the rotor, winding excitation levels and number of excited phases. The Special Problem proved beneficial to all three parties; the ME faculty member learned the application of FEA to electromagnetic fields, the undergraduate student was able to learn FEA and ANSYS opening new job opportunities, and this faculty member started a new research topic. Finally, it is expected to produce a paper out of this work.

(3) Voltage Surges on Electric Motor Terminals When Supplied from a PWM Inverter Through Long Leads

This project consisted of developing a Matlab-based model to analyze the effects of long cables on PWM inverter-fed induction motors. Another faculty member, who teaches the Electromagnetic courses, was enlisted for this project.

An experimental set-up was established in the Energy Conversion Laboratory to verify the results from the Matlab-based model. This research project was sponsored by a motor-drive manufacturer who offered a position to the student after graduation. Unfortunately, the student accepted a better economical offer. Both faculty members continue to interact with the sponsoring company in the form of both funded and unfunded research. Finally, this research project provided a real-world example when teaching the Bewley diagram in ELEG 3713 - Electromagnetics II.

(4) A Microprocessor-Controlled Induction Motor Drive

The objective of this Special Problem is to set up a bench in the Energy Conversion Laboratory for developing microprocessor-based software for motion control applications. It is also expected to use the bench for developing laboratory experiments for a junior course and a graduate course. The microprocessor of choice is the MC68HC16Y1 since Motorola has developed two boards; one board has the microprocessor and the other one has the power module (i.e., the power electronics). The involved undergraduate student has an interest in microprocessors and chose this project because it is an application of microprocessors. This Special Problem is in progress at the writing of the paper.

(5) An Analysis of the Noise Produced by Induction Motors Supplied by PWM Inverters

This Special Problem consists of analyzing a series of measurements corresponding to the noise produced by electric motors. In order to accomplish the goals of this project, the student needs to become familiar with a spectrum analyzer and its interface with a personal computer as well as with signal processing theory. The developed methodology will be used by graduate students for further research in noise and vibrations in electric motors. This Special Problem is in progress at the writing of the paper.

IV. ADVANTAGES OF SPECIAL PROBLEMS USED FOR UNDERGRADUATE RESEARCH

After making intensive use of ELEG 488V – Special Problem for approximately two years, the following advantages are perceived:

Advantages for the undergraduate students

- **Improved motivation:** In general, these undergraduate students seem to improve their motivations for their studies leading to better grades in other courses.
- **Ability to perform independent (research) work:** Students have an opportunity to find resources, innovate and come up with ideas which are part elegance and inspiration. Also, students have the opportunity to learn better methods to solve engineering problems by observing how faculty members and graduate students address research topics. In other words, applying a problem-solving technique is very different from being told how it could be done.

- **Exposure to real-world problems:** Special Problems provide a faster transition from the University to a work environment.
- **Improved resume:** A student mentioned that a recruiter turned the interview into talking about the Special Problem since it was on a technical problem being experienced at the company. Another student thought that he could have an advantage over other graduates with comparable or slightly higher GPAs by having the Special Problem experience since students perceive that companies are looking to hire someone with more than only classroom experience.
- **Time management skills:** In general, students schedule their time while having in mind a deadline (e.g., the end of the semester).
- **Interpersonal skills:** Today, engineering work is done in groups. The undergraduate student normally participates in meetings with personnel from the sponsoring industry. In some cases, the students write a project report gaining valuable writing skills.
- **Acquiring knowledge on a specific (power) topic not offered throughout the curriculum:** With the down-sizing of the (EE) curriculum, Special Problems are becoming the only alternative if credit is desired.
- **Exposure to graduate work:** Students can use a Special Problem to help evaluate if they would like to pursue graduate studies.

Advantages for the faculty member

- **Improved interaction with students:** This is a win-win situation for both the faculty member and the student.
- **Exposure to real-world (industry) problems:** These problems become class project or engineering examples in other courses. A student once mentioned that she prefers those teachers who are in contact with the “outside” real world.
- **Research work is performed:** With dwindling research budgets, Special Problems are proving to be a very effective approach for continuing research work at a nice pace.
- **Teaching becomes even more enjoyable.**
- **Improved interaction with industry:** In some cases, this results in funded research work and/or donated equipment.
- **Publications.**

V. CONCLUSIONS

Although the use of Special Problems and undergraduate students to perform research work was initially originated by dwindling research budgets, it is proving a very beneficial experience to both the undergraduate students and this faculty member. Undergraduate students taking these Special Problems have become the best advertisers. Also, it is the experience of this faculty member that the quality of the work produced by the senior students is of the same quality as that of the work produced by MSEE graduate students. In closing, it must be added that Special Problems require a great deal of dedication by both the undergraduate student and the faculty member.

A Special Problem could become extremely time consuming for both parties, specially when industry is involved. However, the numerous advantages outweigh this disadvantage.

VI. ACKNOWLEDGMENTS

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BIOGRAPHICAL INFORMATION

JUAN CARLOS BALDA received his BSEE from the Universidad Nacional del Sur, Argentina, in 1979, and his Ph. D. degree from the University of Natal (Durban, South Africa) in 1986. He has been at the University of Arkansas at Fayetteville since July 1989 where he is currently an Associate Professor in the power engineering area. He teaches electromechanical energy conversion, electric power distribution systems and power electronics.