

STUDENT PROJECTS AS AN EFFECTIVE TOOL FOR TEACHING INDUSTRIAL CONTROL ELECTRONICS

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1. INTRODUCTION

The widespread applications of automatic control and power electronics have dominated most aspects of industrial applications. As a result, the need for well-trained engineers and technicians who can design, operate, and maintain this high-tech equipment has substantially increased. Different applications of industrial control including data acquisition and signal processing are typically offered within EET curriculum. However, these topics require strong backgrounds in the underlying electrical and electronics theory and therefore offered in senior level courses.

NIU is strategically located in the industrial-belt area extended between Chicago and Rockford (NIU Web Site). While NIU Technology Department (Technology Web Site) has an excellent ABET accredited EET program, it has one 3-credit hour course in industrial electronics control without a laboratory component. To avoid increasing degree requirements, it was necessary to revise the current course to incorporate student's projects and design assignments. Projects are key components of problem-based learning concept that is increasingly the type of engineering technology education preferred by faculty, students and industry. It combines teamwork, hands-on experience, and problem solving to prepare students to move directly into successful technology careers (ATE Center). Furthermore, instructional technologies have become an essential means to promote knowledge and some strategies to improve the classroom environment have been suggested in the literature (Cynthia J. Finelli, 2001).

This paper describes the development and implementation of an industrial electronics control course offered by NIU Technology Department. Five team projects in addition to other circuit design assignments were introduced into the course and include laboratory experiments on industrial-type equipment. The paper is organized as follows. Course description and development are covered in Section 2. Student projects assignments are discussed in Section 3. Instruction Technologies used are presented in Section 4. Assessments and remarks are presented in Section 5, and Section 6 contains the conclusions.

2. COURSE DEVELOPMENT

Many industrial electronics control application involves the use of servomechanism and machine drive circuitry which consist of solid-state devices, such as diodes, transistors, thyristors, MOSFEETs, and IGBTs. Thus, EET students enrolled in this class must have a solid background in this area of study. Therefore, the course has been revised to include digital electronics and electric machines as a prerequisite. Good efforts were made to avoid abstracts and complex control theory. Instead, simple electric circuit analysis was used to explain basics with some algebra and calculus. This applied approach was also followed by the textbook chosen for this course (Timothy L. Maloney, 2001). Emphasis was spent on presenting the material in a consistent and systematic way. For instance, complete details were given to describe circuit layouts and various control schemes as applied to real-word applications.

2.1 Course Description

The NIU Catalog description for this course (TECH 476) is stated as: Basic hardware involved in servomechanism and process control systems. Topics include sensors, actuators, signal conditioners, data acquisition system, power interface, and analog and digital controllers. Course Prerequisite: TECH 376 and TECH 379.

It should be noted that the prerequisite for this course has recently been modified to include electronics (TECH376) and electric machines (TECH379) stated above. Topics covered in TECH476 include the followings:

- Basic control circuit components
- UJTS, Triacs, SCR, and other thyristors
- OP Amps based circuits and applications
- Feedback systems
- Input transducers
- Output Devices
- Example of industrial applications
- AC and DC motor speed drives

3. STUDENT PROJECTS

Given the importance of hands-on experience and practical applications, it was necessary to develop meaningful student projects to achieve the desired outcomes. Although it is not possible to train students for all types of situations that may be encountered in the workplace, laboratory experimentations can provide students with variety of applications so that they can tangibly relate theory to practice and be able to connect and see how the various concepts fit together.

To enhance class participation, students were asked to work in teams and get fully involved in all activities as well as reading assignments and references to understand underlying concepts. Student were asked to write a complete lab report explaining results and implications.

For this purpose, students made use of the equipment located in the EET power system and control lab. It is equipped with industrial-type dc/ac machines, power electronics, and variable-speed drives modules similar to the ones shown in Figure 1. The trainers are of the latest solid-state technology and include speed control, acceleration, low-frequency boost, as well as, different switching mode operations.



Figure1: Power Electronic and Control Trainers

In this course, five student projects (one project per team) covering different drive control applications were assigned. A brief description of each project is given below:

1. DC Variable Speed Drive Analysis: For this project, eight experiments were conducted using the dc variable speed drive trainer. Each experiment analysed a specific component of the drive including acceleration, load regulations, and speed variations.
2. AC Variable Frequency Drive Analysis: This project consists of seven experiments dealing with minimum and maximum speed control characteristics; acceleration and deceleration control characteristics, boost control, and system configuration.
- 3-4. Thyristor-based Speed Controllers: these two projects illustrate the concepts of open-loop and closed-loop control configurations including the limitation on speed, torque, and line current.
5. SCR Single-Phase Bridge Rectifier / Inverter: this project shows how SCR can be arranged to be used as a rectifier or an inverter by controlling the firing angle. Another purpose is to show how this bridge can be transformed into one that has 2 SCRs and 2 diodes. Similar circuits could be used in multiple phase systems; however, they are more complex and require more efforts.

4. INSTRUCTIONAL TECHNOLOGIES

Most NIU classrooms are fitted with overhead projectors, video/audio equipment, and a computer connected to the Internet (Richard Marcellous *et al.*, 2002). Teachers can download files, use PowerPoint, and display audio/videos educational products. To enhance the learning process in this course, various instructional technologies were developed and used. These are:

A) PowerPoint Presentations

Most course lectures were covered using PowerPoint. A great deal of time was originally spent preparing these presentations; however, it was considered time well spent since they can be reused with minor modifications. Good efforts were directed towards keeping the text to a minimum with lots of illustrations, diagrams, and examples.

B) Blackboard

Blackboard is web-based software used by NIU for on-line information and course offerings (NIU Blackboard). Students in this course were given access to view on-line information, such as syllabus, grades, periodic announcements, homework assignments, and solutions. Additionally, they were able to send e-mail messages and communicate as needed.

C) Computer Simulation

Computer simulation was another effective tool used to help students design and analyse control circuits. For instance, several design assignments were given for which Multisim, a newer version of Electronics Workbench, was used to simulate control circuits within the manufacturer's specifications.

5. ASSESSEMENTS AND REMARKS

The course described above was offered during fall 2004. Final results showed excellent student retention and success rate. Out of eleven students enrolled during that semester, only one student dropped the course. All students passed with an average of B (80%) or higher, and none has flunked the course. Final grades were based on two exams (20% each), Projects (30%), and Final (30%). Student projects were evaluated based on the submission of a formal report, a 10-minute team presentation, and peer evaluations. A project peer-evaluation format is shown in Table 1 including student scores and total average for each project.

Table 1: Student Project Peer Evaluation

Presentation	AC Variable Speed	DC Variable Speed	Thyristor Circuits	SCR Speed Control I	SCR Speed Control II
Clearness/Effectiveness	4.75	4.75	4.4	4.3	4.55
Quality/Demonstration	4.7	5	4.8	4.3	4.67
Data/ Results/Analysis	4.6	5	4.5	4.5	4.78
Questions/Discussion	4.7	3.87	4.3	4.5	4.55
Total Average	4.69	4.65	4.5	4.4	4.64

Score (Excellent: 5; Good: 4; Average: 3; below average: 2)

It was interesting to show how students evaluated each others compared to the teacher. As indicated in Figure 2, peer evaluation was higher than the instructor for all these projects.

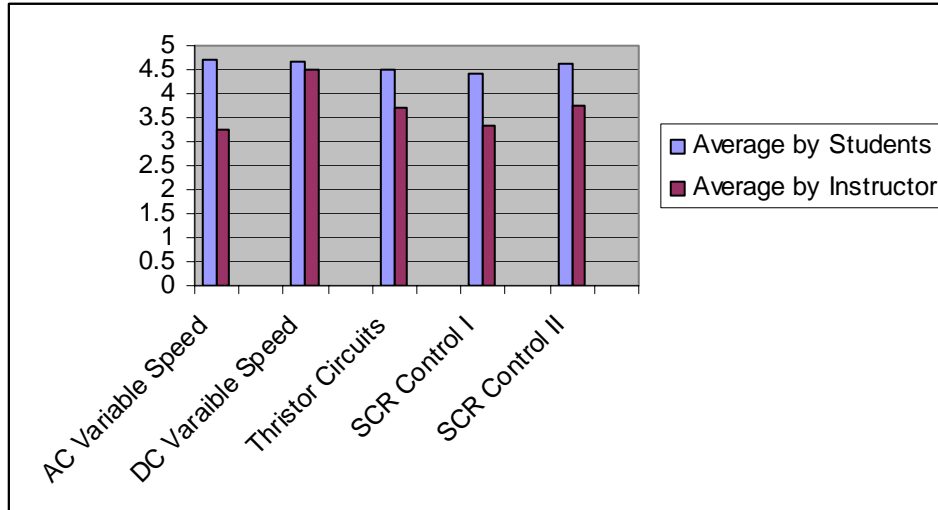


Figure 2: Instructor Evaluation versus Peer Evaluation

Students also found a field trip to a local company specializing in automobile instruments to be enjoyable and very informative. They visited the company engineering division and toured the production area where assembling, final testing, and packaging were performed. They also attended an on-site presentation about the various sensors and actuators used to measure speed, temperature, liquid level, and other parameters used in this industry.

As for future development and improvement of this course, it is sought to be in the area of data acquisition, signal conditioning, noise reduction, and power interface which are essential in computer-based industrial control. This would require the attainment of additional equipment to support lab experimentation in these important fields.

6. CONCLUSIONS

This paper described the modification of a typical industrial electronics control course to incorporate student projects into a modern engineering technology program. Several strategies to engage students in the classroom were developed and discussed. These techniques encouraged students to work in teams and actively participate in research and self-study to reinforce their learning process. Five team projects dealing with different industrial control types were presented and discussed in this paper. These projects included AC and DC variable speed drives, SCR-based motor control, and operation of converter/ inverter circuits. Future improvement for

this course includes covering more topics dealing with computer-based industrial control such as data acquisition systems, signal conditioning, and power interface.

REFERENCES

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