An Innovative Instrumentation and Controls Laboratory for Engineering Technology

R.H. Cockrum, R.J. Kennerknecht, E.T. Ibrahim, and G.K. Herder

California State Polytechnic University
3801 W. Temple Avenue, Pomona, California 91768

ABSTRACT

The Instrumentation and Controls Laboratory at Cal Poly Pomona combines computers, virtual-reality simulators, and advanced software with industrial hardware into an integrated multi- disciplinary environment. This environment allows tailoring the laboratory experience to the needs of different majors, and hence, enhances the effectiveness of course delivery. This paper presents some of the experiences for engineering technology students in this laboratory.

Introduction

The increasing speed with which technology is changing forces educators to incorporate innovative methods in order to keep pace with technical advances. Several papers (1-10) of the last decade reveal a common theme: Engineering is a holistic integrative process and thus engineering and engineering technology education should be designed toward that end. From innovative teaching methods come innovative ideas that industry needs to achieve a leadership role or to gain markets. The mission of engineering technology educators must include the cultivation of each student's ability to bridge the boundaries between disciplines and make the connections that produce deeper insights(2). An instructor's ability to deliver effective engineering technology education can be greatly enhanced with modern innovative laboratories which include virtual-reality and physical simulators.

The Instrumentation, Simulation, and Controls (ISC) laboratory at Cal Poly Pomona was established to give students in engineering and engineering technology the insight needed to analyze, visualize and synthesize control and instrumentation systems. Students have at their disposal two control panels, a liquid level panel and an analytic panel. These panels can be controlled and monitored by several methods such as a Distributed Control System (DCS), stand-alone controllers, and bench top PC computers. There are twelve student work stations equipped with computers, printers, oscilloscopes, power supplies and signal generators. The expense needed to equip each student station with a full complement of data acquisition, signal conditioning, and analysis equipment is beyond the budget of most universities. By using virtual instruments (VI's) students can create the equipment that is needed for their project or experiment. There are two basic programs installed on our laboratory computers: LabVIEW by National Instruments and MatLab/Simulink by the Math Works. By using computers and the appropriate software, the students can perform system simulation before a real hardware system is investigated. By using modern technology, the contents of some courses have been changed to include more design and testing of real hardware. This has been made possible because the once time consuming tasks of manual calculations, data collection, and analysis are reduced to a manageable amount. Figure 1 is an overview of the ISC laboratory. Additional information on the equipment and capabilities of the ISC laboratory is given in references (14 & 15).

Figure 1. An Overview of the ISC Laboratory

The Approach

The classic approach to teaching instrumentation to engineering technology students was to show them different types of instruments and tell them what they are used for in engineering. This approach assumed that technology students could not design and build instrument systems because of a lack of mathematical abilities. By using these new techniques any student can design, build and test instruments with a minimum amount of mathematics skills. The programs used in this laboratory contain many function modules in their libraries which simply require the student to select the function and connect it with other function modules graphically on the computer screen and create a complete system. Figure 2 and 3 show a simple system used to control pH in our analytic system. The diagram shown in figure 3 shows the individual function modules that were selected from the LabVIEW library and graphically linked together. It can be seen that there are no complex functions needed to create this type of system.

Our laboratory is set up to teach all types of engineering and engineering technology students about instrumentation and control systems. Engineering technology students have used this lab for special projects since its dedication in 1992. Courses designed around the new lab capabilities started in Spring 96. We now teach engineering technology students instrumentation systems, including sensors and data acquisition circuits in this laboratory.

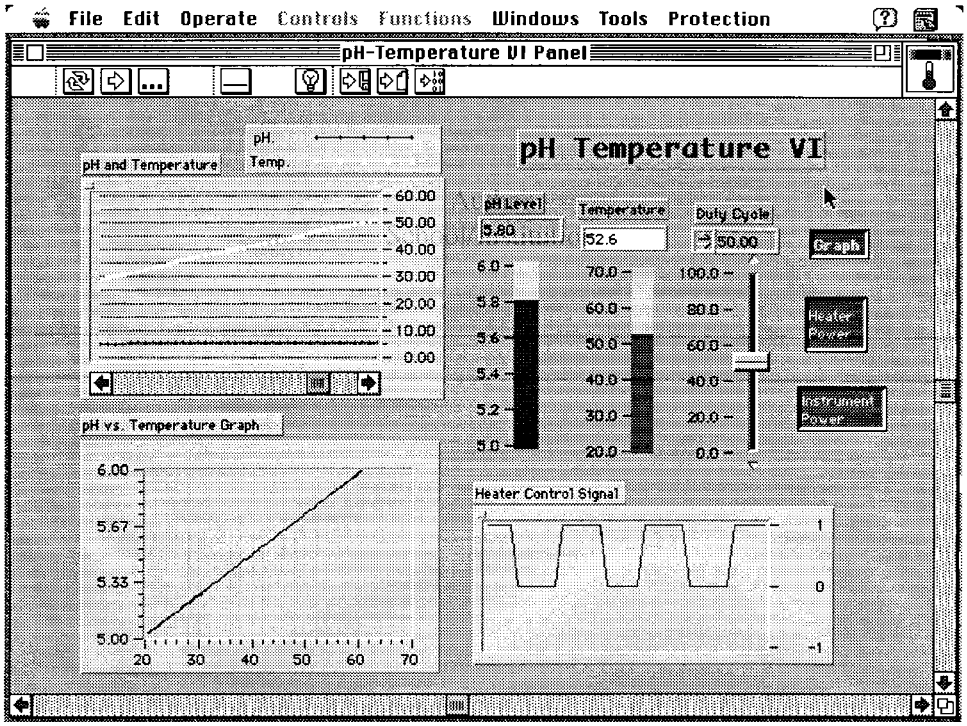

Figure 2. LabVIEW Front Panel for the pH-Temperature System of Figure 3

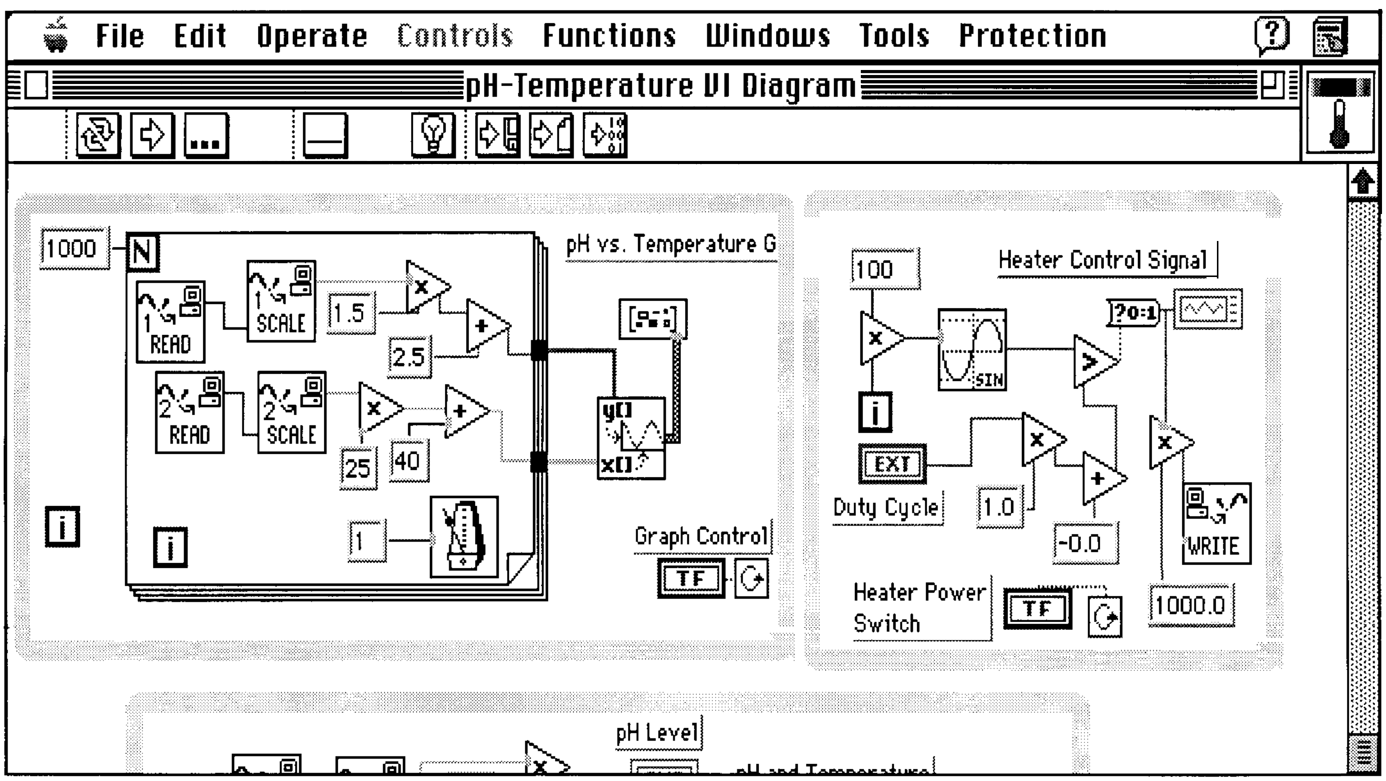

Figure 3. Part of LabVIEW Diagram for the pH-Temperature System of Figure 2

This information is then used in three courses: Electronic Instrumentation, Biomedical Instrumentation, and digital courses where Analog to Digital and Digital to Analog converters are discussed. Both of these courses are taught at the senior level as electives. The laboratory is. also capable of teaching the basics of instrumentation for mechanical and construction technologies. Another area where this laboratory can be used to teach technology students is in conventional control systems analysis and design. The one common subject that links all engineering and technology disciplines is control systems. So, it is very important to introduce technology students to as much control systems applications as possible.

In an engineering class on conventional control systems circuits are usually described by writing the differential equations of motion or operation. These equations then are transformed into the transform domain for manipulation and to develop a design. Such mathematics training is usually beyond that required for technology students. On the other hand, transfer functions are readily available in literature for motors, drivers and other control components. A few sessions on modeling mechanical loads as summation of forces or torques at a velocity node using transforms of inertias, dampers and springs equations allows the student to construct actual transfer functions without ever handling a differential equation directly. Figure 4 shows a actual control system created using this method with Simulink.

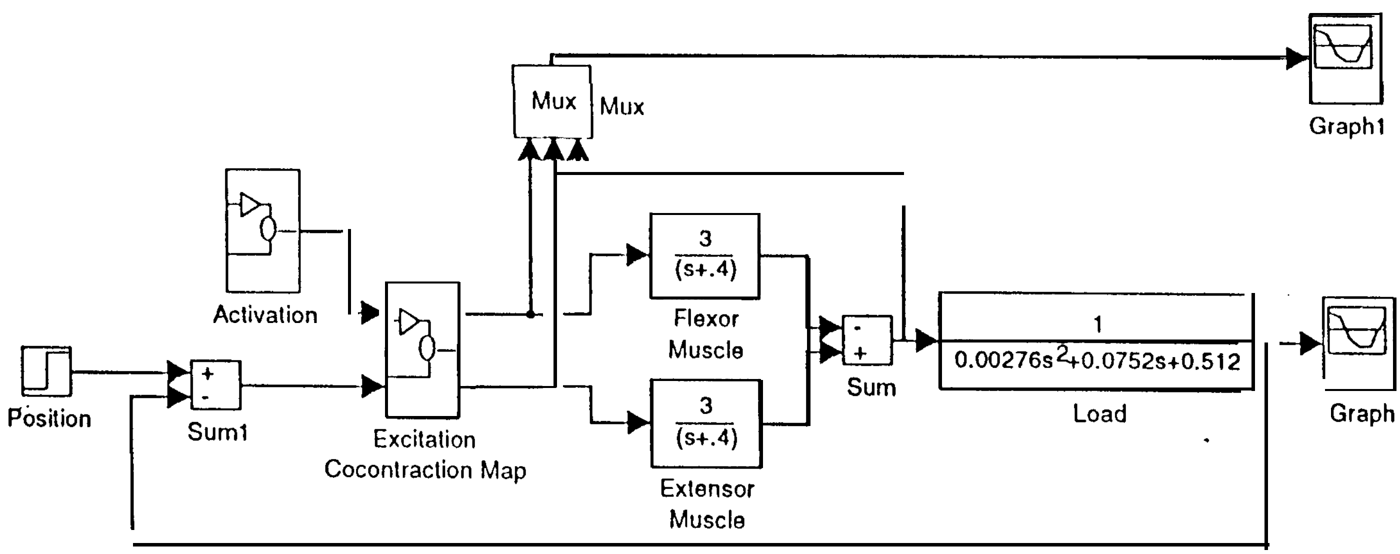

Figure 4. Simulink Model for a Single-Joint Muscle

The format of our laboratory classes has been changed to offer mini-projects and stand alone experiments. These mini-projects are intended to design and build complete instrumentation systems and then compare their performance to real instruments. Students in the laboratory usually divide into groups of two or three. The group is usually required to incorporate the following into their project:

- selection of a challenging project that can be completed in the allotted time and is not cost prohibitive. This first step is usually difficult for the students and thus requires considerable consultation with the instructor.

- use of commercial equipment for calibrating data acquisition virtual instruments, transmitters and converters.

- development of LabVIEW Virtual Instrument that will acquire data, manipulate it and appropriate display an output.

- designing and building necessary signal conditioning circuits.

- interfacing real equipment and Virtual Instruments.

- analyzing the test results and making recommendations.

Conclusions

Effort was made to ensure that advanced technology and computing tools help students with understanding of the physical phenomena and not hide it. Care was also taken not to overwhelm students while they are going through one of their first technology design experiences and students reaction has been primarily positive. Technology students are eager to learn and appreciate having access to this type of technology. Student and faculty reactions and experiences in all classes taught in this lab have been analyzed in an attempt to provide guidelines that would make integrating physical and virtual realities a pleasant and fruitful education experience. Some of these are highlighted below:

1. A new approach to instrumentation education has been adopted at Cal Poly Pomona. Lectures continue to focus on basic principles whereas laboratories emphasize practical design.

2. Students prefer mini-projects over single experiments because they were rewarding and challenging.

3. Even though the software was unfamiliar to the students, they did not feel that it was too hard to learn.

4". Adequate guidance is vital, A cook book approach is counter productive and should not be an option. Instructions should be clear and sufficient. Deadlines should be feasible and firm. Group and individual assignments should be delineated to give each student experience both as a team member and an independent thinker.

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