ENHANCEMENT OF ME LABORATORIES WITH INTERDISCIPLINARY EMERGING TECHNOLOGIES

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Abstract

This project is based on the hypothesis that the balanced integration of interdisciplinary design, laboratory experiments, and computer-control technologies with engineering curricula is a key element for enhancing engineering education. To accomplish this objective we have undertaken the following four major activities:

1. Enhancement of the mechanical **measurement** laboratory
2. Enhancement of the **mechatronics** laboratory
3. Addition of control related experimental workstations for course on **control**
4. Development of a computer controlled **heat transfer** experimental workstation

In the **measurement laboratory** we are installing five different experimental workstations with varying degrees of difficulty. Each workstation is a combination of computer interfaced modern instruments, such as, a digital oscilloscope, signal generator, power supply, digital multimeters, some of the fundamental electronics circuit boards, computer with data acquisition facility, transducers, such as, strain gauge, LVDT, accelerometer, and encoders. In addition, dedicated experimental workstations have also been included for analysis of dynamics and vibration, heat transfer, and stress.

For the enhancement of the **mechatronics laboratory,** we are upgrading educational robots for advanced workspace modeling. We are also acquiring multiple sets of intelligent model building kits for students' class projects on integrated system design. In addition an inverted pendulum balancing set up will be provided to conduct real time control experiments. This set up along with the dynamics and vibration set up will also be used to enhance teaching in the course on **control**.

A dedicated workstation for temperature measurement and control will be installed in the measurement laboratory to test the fundamentals of heat transfer using a computer controlled linear heat conduction testing plant. Using this set up students will control multiple parameters related to thermal conductivity measurement. This set up will also be included in the **heat transfer laboratory** to conduct experiments on advanced heat transfer analysis through computer aided data acquisition. This project is funded by BOR Support Fund (Contract # LEQSF-ENH-TR-52).

1. Introduction

The enhancement project has been implemented within the College of Engineering, Southern University, Baton Rouge (SUBR) – a predominantly undergraduate institution and one of the Historically Black Colleges and Universities.

The undergraduate Mechanical Engineering program, accredited by the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology (ABET), consists of 135 hours. Mechanical engineering graduate program currently offers two areas of concentrations in thermal and material sciences. In addition the Mechanical Engineering Department offers most of the fundamental and interdisciplinary courses like freshman engineering design, mechanics of materials, dynamics, control, thermodynamics, mechatronics etc.

The measurement, control and mechatronics program commences with a freshman course titled Freshman Engineering II (ENGR 130) which introduces all freshmen engineering students to computer programming and problem solving methodologies. The second year class offerings include numerical methods (MEEN 221) class where the use of computer programming to solve various engineering mathematical equations is taught. While in the third year the mechanical measurements (MEEN 356) course is offered. This course has an accompanying laboratory where the students are exposed to various fundamental measurement instruments and experiments related to mechanical and electrical engineering problems. The control course (MEEN 456) offered in the final year completes the series of courses in this particular program. Mechatronics technology is emerging from the close fusion of Mechanical Engineering, Electrical Engineering and Computer Science. The essence of mechatronics is the application of intelligence to the operation of physical systems. In order to accommodate this emergent technology in the engineering curriculum, Mechanical Engineering Department developed an interdisciplinary mechatronics course (MEEN 464) and a laboratory with support from National Science Foundation and Board of Regent (during the academic year of 1996-97). Most of the equipments in these laboratories were outdated, and are in the process of being replaced via this project.

2. The Enhancement Plan

The goal of this project is to provide the state-of-the-art laboratory equipment and instruments for teaching and research in the mostly interdisciplinary field of Engineering. This will enhance student learning via experiments. It will also result in greater engineering and economic impact through innovative research. The expected results are increased teaching effectiveness and research competencies in the use of state-of-the-art of laboratory equipment. The main objective of this project is the enhancement of current measurement and mechatronics laboratories with modern equipment and experiments related to interdisciplinary emerging technologies.

Objective 2.1: Enhancement of Measurement Laboratory

Proposed activities:
The plan here is to develop at least eight (8) experimental workstations with varying degrees of difficulty. We have already set up four workstations that are dedicated to the introduction of basic measurement instruments like digital multimeter, digital oscilloscope, signal generator, power supply etc. Additionally, four other workstations are in the process of being set up.

2.1.1 Voltage measurement and signal conditioning.

Four similar workstations equipped with general lab instruments, such as digital oscilloscope, power supply, signal generator, two digital multimeters, bridge and amplifier circuits, that can be interfaced with computer have been developed. In addition various transducers - resistive, inductive, capacitive, photoelectric, etc. - will be available for experimentation (Figure 1).

2.1.2 Digital and Analog Signals:

Electrical signals external to the computer come in two flavors - analog and digital. Analog signals are (in this case) voltages, with information attached to the voltage value. Every voltage value represents unique information. The actual resolution of an analog signal depends on noise in the system, and the precision of analog-digital converters used to get the signal between the computer and the outside world. Digital signals are also characterized by voltage than can have only two values. In this exercise, students will develop various programs using low level software tools for the data acquisition card and associated interfacing electronics. Students would be able to construct analog signal generators capable of producing sine, square, or triangle waves with variable amplitude and frequency (Figure 2).

2.1.3 Stress and Strain measurement:

Experiments are being developed to measure static as well as dynamic stress and strain using the mechanics of a cantilever beam, strain indicator, accelerometer, oscilloscope etc. An independent workstation is being developed with related specialized equipment to conduct these experiments.

2.1.4 Dynamics and vibration experiments:

A dedicated workstation to study the principles of dynamics and vibrations has been developed using a classical spring mass damping system. In the measurement laboratory experiment more emphasis will be given on the aspect of sensors, system parameter measurements and system responses.

2.1.5 Temperature measurement and data acquisition:

Here, students are introduced to different temperature measurement sensors and various principles of temperature measurement using thermocouple, thermister etc. However, a dedicated workstation for temperature control and measurement is being installed to test the fundamentals of heat transfer using a computer controlled linear heat conduction testing plant. Using this set up, students will measure and control multiple data related to thermal conductivity measurements.

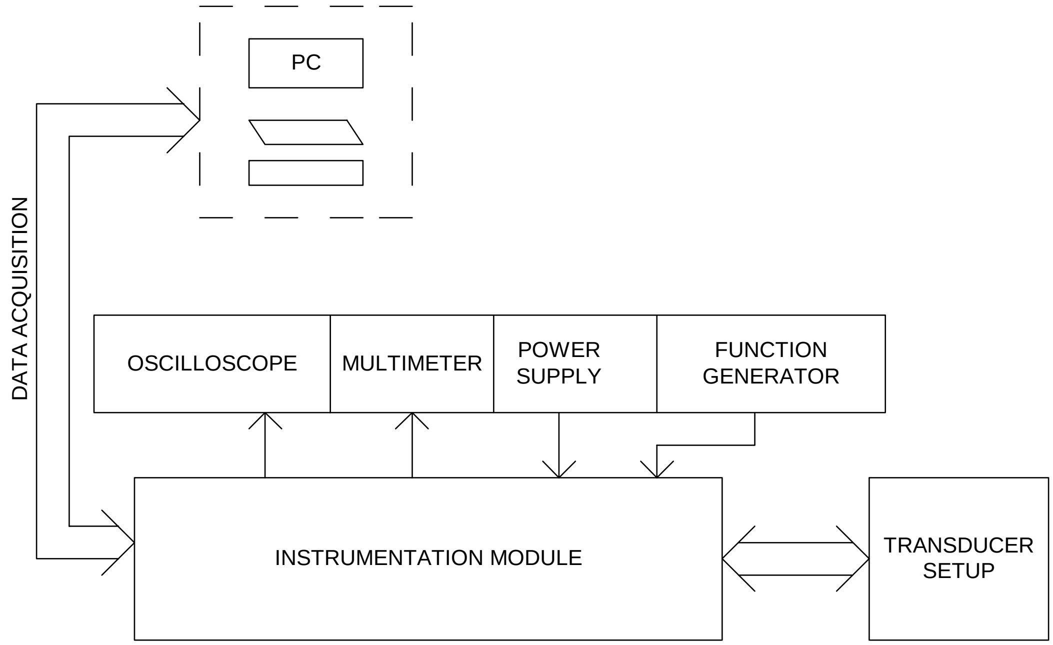

Figure 1. Measurement Lab Workstation

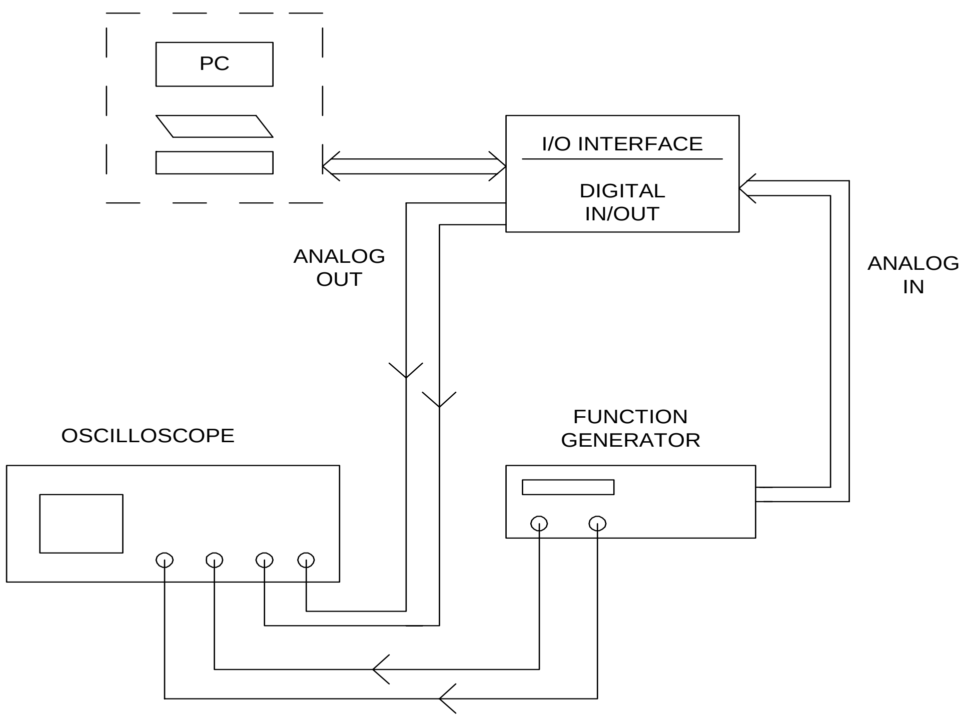

Figure 2. Data Acquisition Set Up

2.1.6 Inverted pendulum experiments.
These experiments are focused toward control of the non-linear dynamic system and stability analysis. Experiments related to plant identification and dynamic model building will be included in the measurement laboratory course. This set up will be used for experimentation in the control course. This experimental plan will also be applicable to the dynamics and vibration experimental set up (see objective 2a.1.4).

Objective 2.2: Enhancement of Mechatronics Course and Laboratory:

Proposed Activities:
Mechatronics is laboratory oriented towards different types of systems, software and equipments. It has been observed that all the equipment or instrument oriented laboratories (robotics, instrumentation, mechatronics, control, and even manufacturing) have some common interdisciplinary elements such as electrical signals, computer control, and mechanical systems. These are areas that are too broad in the context of the current engineering curriculum: It is difficult to teach many different types of equipment and systems in one laboratory oriented course - and very challenging for students to work with. To reduce these difficulties, an integrated approach (Figure 3), would be taken in developing the lab materials. The same experimental setup could be used to design experiments for different courses with various levels of knowledge and degrees of difficulty. The students will revisit the same experimental setup in different courses - with the complexity and objective of the experiment changing at different levels.

2.2.1 Robot programming:

Educational robots and related workspace modeling equipments from previous enhancement projects are already in place. The plan here is to upgrade four robots for advanced workspace modeling. Each of these robots will be provided with a new teach control box, power supply and a rotary table. The control of the rotary table will be included with the robot as a separate motor and will provide an additional degree of freedom. This additional modeling facility will allow the students to design complex real time systems using multiple physical systems and multiple processors.

2.2.2 Smart product design:

The basic requirement of a smart product design project is the integration of intelligence, electronics, and mechanics/structure to achieve a product that could not be built otherwise. This generally requires sensing the environment, signal processing, decision making, and control of a physical device. It is difficult to design all the aspects of a smart product in a single course as the bulk of associated background materials are specialized skills in the areas of software and hardware. In order to overcome these problems special attention will be given to the level of abstraction, and have a small project for the course. Students will use the Lego Mind Storm kit to design the smart product. In the next phase, students will integrate their products with robots in order to develop real time integrated systems as a final class project of the Mechatronics course.

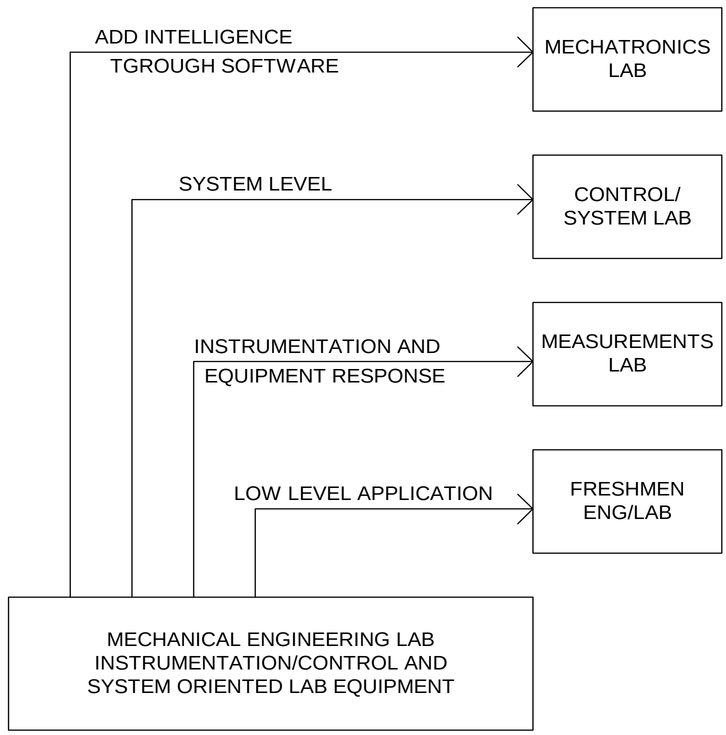

Figure 3. Integrated Approach

2.2.3 Control experiments:

Here, students will test various control algorithms using the inverted pendulum setup. This set up has been installed in the measurement laboratory, and the development of the experiment is in progress.

Objective 2.3: Enhancement of Control Course with Laboratory:

Proposed Activities:

2.3.1 Control Laboratory

Mechatronics and measurement laboratory equipment are utilized in control course (MEEN 456) instruction. In Mechanical Engineering Department there is no separate laboratory facility for the control course. The current control course will be enhanced with the addition of experiments using the dynamics and vibration set up and the inverted pendulum workstation.

Objective 2.4: Enhancement of Heat Transfer Laboratory with new Experiment:

Proposed Activities:

2.4.1 Heat Transfer Laboratory

The Mechanical Engineering curriculum includes a senior level Heat Transfer Laboratory course (MEEN 444). Computer controlled heat transfer equipment of the measurement laboratory will be shared by this course to conduct experiments on advanced heat transfer analysis through computer aided data acquisition. This system is being set up in the measurement laboratory.

3. Impact of this Enhancement project

This project will facilitate the expansion of interdisciplinary courses offered at the Mechanical Engineering Department. The new setup of experiments directly impacts the following courses: *MEEN 356: Mechanical Measurements, MEEN 456: Engineering modeling and Control, MEEN 464: Mechatronics, and MEEN 444: Heat Transfer Laboratory:*

This project will expose students to a broad spectrum of engineering education than would have otherwise been possible. It will have a significant effect in the development of human resources by preparing students for the work force. The enhanced curriculum would increase the undergraduate students' desire and motivation for graduate studies in the areas related to intelligence, product design and mechatronics. It will also impact elementary and high school students as they will be taught rudiments of Mechatronics and implementation of intelligence via the Summer Engineering Program for Louisiana students undertaken by the College of Engineering through support of the National Science foundation. These students may be spurred to acquire a college education and possible pursue engineering.

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