Digital and Analog Circuit Measurements in an Introduction to Engineering Freshman Course

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ABSTRACT[1]

Students measure basic terminal characteristics of electronic devices and circuits in a seven week laboratory module. This laboratory module is one quarter of a Fundamentals of Engineering course given to all' freshmen at New Jersey Institute of Technology. The module culminates in a simple circuit or system design produced by each team of four students.

Since entering freshmen have limited background, a measurements approach was utilized to rapidly introduce students to basic electrical and electronic devices. A minimum discussion of the applicable theory was presented, as needed, in order to allow the students to verify their measurements.

Test circuits were constructed on a standard "proto-board" or from assembling simple kits of parts. Devices studied included: (1) diodes, (2) transistors, (3) light emitting diodes, (4) phototransistors, (5) photoresistors, and (6) solar cells. The terminal characteristics of several digital integrated circuits were measured, namely gates, counters, timers and clocks. The kits were utilized to build application circuits. These circuits were: (1) a digital combination lock, (2) a sensitive light actuated relay (3) digital dice and (4) a solar array battery charger.

Student teams assembled and tested the operation of each kit. Teams discussed possible application of these circuits. Based on the measurements taken during the first four weeks of this module, a design project is assigned. Each team successfully complete the design of a circuit or system. During the final class session, teams present their work orally and submit a short report on the working design.

INTRODUCTION

At New Jersey Institute of Technology (N. J. I. T.) an ongoing process of integrating design into the freshman program has continued. The first step of this process was the development of a required one- " semester course, namely Fundamentals of Engineering Design (FED-101). This paper discusses the elec-

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trical engineering module, representing one quarter of the freshman FED-101 course. For the past five semesters the EE module has been an intense laboratory oriented introduction to direct current electricity, basic electronic devices and circuits. In the fall 1995 the EE module was expanded to include digital devices. Application circuits were constructed and tested. Students were then involved in simple system design using the circuits assembled and tested in the laboratory.

LABORATORY MODULE CONTENT

Freshman students with no background in electricity are rapidly introduced to characteristics of electric circuits and components through laboratory measurements. The module begins with a study of voltage, current, and resistance. Simple circuits are wired and measurements are made using a digital volt-ohm meter. Resistor color code is explained and verified by ohmmeter measurement. Ohm's law and Kirchoff's laws are verified by hands-on laboratory measurements.

Devices are studied by measurements of the input-output characteristics. These included: (1) incandescent lamps (2) diodes, (3) light emitting diodes, (4) phototransistors, (5) photo- resistors, and (6) solar cells. Additionally elements of digital circuits were studied by laboratory measurements to confirm the truth tables. Standard gates, counters, timers and clock integrated circuit chips were wired and tested. Several analog and digital circuits were assembled from basic kits to demonstrate the application of the devices studied.

The measurements made in the laboratory were carefully documented in a bound laboratory notebook. Students learn to use several instruments including a Iightmeter, DVOM and a logic probe. Proper data recording practice and curve plotting are explained. The completion of the work in this module requires the design of a system using the concepts learned and the devices and circuits studied in this laboratory. Each student team chooses a project from a list suggested by the instructor or may propose a project approved by the instructor. At the last class meeting students submit a written report, make an oral presentation, and demonstrate a successful project.

EQUIPMENT AND COURSE ORGANIZATION

Class size for this introductory course is limited to twenty students. Each class is taught by an senior professor with solid engineering design experience. A teaching assistant with good laboratory skills and the ability to communicate, is assigned to each class. Students work in groups of up to four members. Laboratory equipment is assigned to each group. This equipment is stored in their personal locker located in a dedicated laboratory room used solely for this course, FED-101. Students have access to-this laboratory outside of the scheduled class hours whenever the building is open.

The equipment given to each group consists of a digital volt ohmmeter, (DVOM) a dc power supply together with a "proto-board", and a kit of electrical parts, wires and tools. The high quality lightmeters and other special equipment are issued as needed by the course instructor or the teaching assistant.

Groups of students keep a common laboratory notebook, and progress through the module together. Laboratory work is carefully supervised and most students find it to be very demanding. Group members interact and share leadership roles as they progress through the module experiments.

A very important aspect of this overall freshman experience is the "coupling" of the FED-101 course with a humanities course taught to the same students by a humanities instructor who is part of the team in the freshman design course. This instruction reinforces students in learning technical writing; group interaction and oral presentations. The two instructors work together and help students overcome deficiencies identified as common to both courses. Students, for example, practice their oral presentation of the design project in the humanities class.

EXPERIENCE IN OFFERING THE LABORATORY

In the fall of 1995 trial two sections of freshman were given the analog-digital EE module. A senior professor and two teaching assistants taught these students. This is a labor intense course offered by the department of electrical and computer engineering. Senior faculty with design experience are utilized to teach this freshman course.

Design projects included: (1) a revolutions-per-minute-counter using a sensitive photoelector, light source and digital timer and counter. (3) a digital based game using logic chips, timer and clock, (3) a solar powered circuit that is an automatic 'night light" using a transistor circuit, solar cells and a battery, (4) a sensitive burglar alarm using a digital combination lock circuit, light detecting circuit, and logic chips, (5) a fluid level detector using a phototransistor, light source, and logic chips.

CONCLUSIONS

Freshman students are capable of producing significant working designs in a short time provided they receive intense attention and guidance.

Students generally find the EE module as interesting and challenging.

Digital concepts including logic design is more easily learned by students than analog circuits.

A hands-on laboratory approach to learning basic electrical and electronic concepts is appropriate for freshman students with little background.

The use of simple kits provided the students with the opportunity to design systems by interconnecting building blocks.

Extensions of the concepts used in this module will allow an interdisciplinary approach by linking the electronic systems with the mechanical engineering module through instrumentation. A pilot program to accomplish this is currently being run in two sections for a Spring 1996 semester.

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Professor Strano graduated from Newark College of Engineering in 1959. He earned the M.S. degree in electrical engineering from there in 1961 and completed the doctorate in biomedical control engineering from Rutgers University in 1969. He served as a faculty member of the electrical and computer engineering department at NJIT since 1966, and was department chairman from 1976 to 1987. Professor Strano is an engineering consultant to various industries, and is currently a professor in the Electrical and Computer Engineering department at NJIT.