Integrating Graphics and the Concurrent Engineering Design Process into Electrical Engineering Education

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ABSTRACT

This paper describes a laboratory exercise performed by Electrical Engineering majors taking a first course in electrical circuit theory. The goal of this exercise was to familiarize students with engineering drawings, concurrent product engineering and manufacturing considerations within the context of design applications for an electrical circuit theory class. Since much of engineering design culminates in a manufactured product, the ability to read an engineering drawing should be a developed communication skill. This would promote communication between engineers during the entire design process, thus advancing the progress of the design paradigm termed "concurrent engineering". These skills can be taught by integrating engineering drawings into existing design projects. This paper describes the integration of graphics and rapid prototyping into an electronic circuit design class and the outcome of the project.

I. Introduction

In the context of concurrent product engineering, the end result of an engineering design is a manufactured product. Engineers with backgrounds from different disciplines lend their specialized skills to a project as the product design matures. In the concurrent design environment, the lines of communication are open between engineers during the beginning process of design and throughout the various stages of refinement. This can be fostered at the undergraduate level by introducing engineering students to the primary language of the different disciplines. The problem for Electrical Engineers, is that at many institutions, the curriculum does not leave room for a course in engineering graphics. Although it is not the primary responsibility of Electrical Engineers to produce drawings, as a communication tool, these drawings are important to the design process and the functionality of the device. In the short term, the skill to interpret engineering drawings is necessary for senior projects. Students must be able to communicate with machinists in order to have components built. In the long term, this is a skill needed for industrial work where an engineer will be expected to read drawings, evaluate how their design will be effected by the physical structure of the device and present addendums to the drawings.

This paper describes the integration of graphics into an introductory circuit theory class for Electrical Engineers.[1,2] As part of course and the Accreditation Board for Engineering Technology (ABET) requirements, students are required to follow a course of study that integrates design into the curriculum.[3,4] During the semester the students complete design projects. The topics for the projects are derived from real world applications of the circuit theory taught in the classroom. One such project is described in this paper, a light reflection meter. The addition of the study of the drawings of the physical housing for the electrical device brings the study of the functionality of the device into a broader context.

II. Design Project

As part of the course requirements for an introductory circuit theory course, student were given the task of designing a light reflection meter. This instrument activates a light source and receives a reflection through the light sensor. The amount of light reflected is related to the proximity of the reflective surface and thus to the output voltage for the circuit. The possible application for this device is a motion sensor, liquid level detector or a proximity sensor. In this specific project, the application focused on designing an instrument that would be employed as part of another independent robotic research project, sensing the proximity of a robotic end effector to the wall of a maze. The proximity sensor would be held in a robotic gripper and aimed at the surface that is to be tracked by the robotic arm. See Figures 1 and 2.

In the first phase of the project, the students were given electrical specifications, cost design criteria and a list of deliverables.

Electrical Specifications

- Full light implies that the sensor is receiving the maximum reflected level of light.
- Characterize the photo resistor in the presence of full light and darkness.
- Build a circuit that will provide a voltage reading related to the light level received by the sensor, such that the output in the presence full light is five Volts and the output is zero Volts in darkness.
- Analyze the power consumption of all components.

Cost Criteria

- Use standard component values.
- Calculate and justify the cost of the circuit.

Deliverables

- Provide a design description.
- Run a PSpice[1] computer circuit simulation.
- Build the prototype circuit.
- Report experimental results.
- Perform a cost and safety analysis.

First the student passes their circuit design description and a computer generated circuit simulation to the instructor for evaluation. One of the goals of this project was to give the students exposure to the multi disciplinary, concurrent engineering design process. Therefore, in the next phase of the project, the students were given access to the design drawings of the instrument housing that would enclose the light source and the light sensor circuit. A rapid prototype paper cutout model of the instrument housing, generated in ProtoForm[5], was also included.

The engineering drawings and prototype of the instrument included,

- a picture of a 3-D model (produced in AutoCAD[5]),
- dimensioned engineering drawings (produced in AutoCAD) and
- a rapid prototype model (produced in ProtoForm).

The graphical materials were produced using the software programs AutoCAD and ProtoForm. The 3-D model was first produced in AutoCAD and then rendered to a dimensioned engineering drawing. The engineering drawing included top, front and right side orthographic views along with an axonometric projection of the instrument. ProtoForm is a type of rapid prototype software. It takes the 3-D model and produces a paper model of the instrument. See Figure 3. This is useful for visualizing the 3-D structure.

In the classroom, the instructor leads the reading of the drawings. The students were also made aware of the available resources for producing computer generated drawings. Then, the discussion focused on the needs of the electrical device and the functionality of the model. The questions, “How does the physical structure affect circuit components and sensors?” and “Can the design be improved in order to maximize functionality?” were posed and debated. The group agreed upon changes to the drawings and the presentation of the results was made in class. In the last phase of the project, the students build and tested the prototype circuit. A formal project report was generated by each student.

This exercise was intended to mirror the design process that engineers experience in the workplace. Most students had no prior background in producing mechanical drawings and this project is not meant to be a substitute for this training. The fact is that as electrical engineers, these students will be responsible for reading mechanical drawings and communicating the needs of their project to those who will produce the drawings. This project does give the student some experience in this area and therefore some working knowledge of the subject matter.

III. Student Feedback and Conclusions

Students were asked to evaluate the exercise and the response was unanimous that this was a worthwhile experience. Most students commented that after the exercise they could read a basic drawing enough to comprehend the function of an instrument.

In conclusion, engineering drawings are a means of communication. Although a whole course may not be available to Electrical Engineering students, exposure can be achieved by integrating engineering drawings into existing design projects. This not only enhances the design experience, but it also prepares students for senior projects and industry where they will be required to read and produce engineering drawings.

The future plans for this circuit theory class are to continue to integrate the drawings as part of the design projects. The main accomplishment of this exercise is that it improves communication skills and exposes students to another part of the design process before they are faced with the task at senior project time. This also broadens the design experience and exposes the student to concurrent engineering issues and rapid prototyping methods.

IV. Acknowledgment

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V. Bibliography

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VI. Biography

K.A. KORZENIOWSKI completed requirements for the Ph.D. at Brown University in 1993. Dr. Korzeniowski is currently an Assistant Professor at the United States Naval Academy, Annapolis, MD, in the Department of Electrical Engineering. Her current research work at the USNA focuses on developing controllers and algorithms for robotic systems to perform object recognition, manipulation, and exploration through sensor fusion.

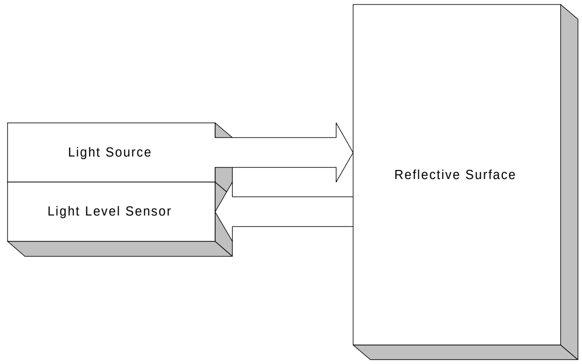

Figure 1: Proximity Sensor:
Light Reflection Meter

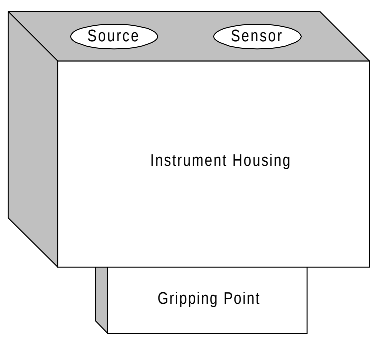

Figure 2: Proximity Sensor:
Instrument Housing

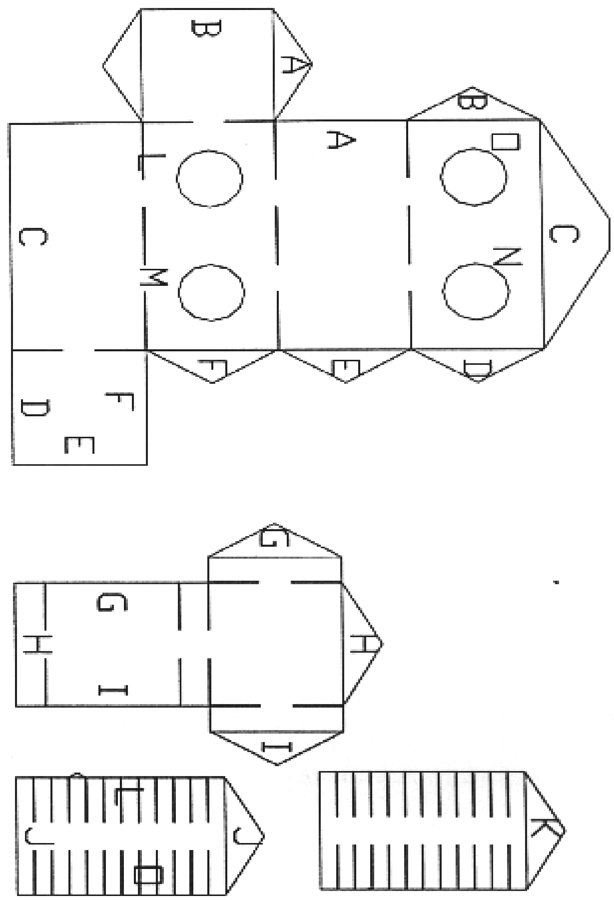

Figure 3: ProtoForm, Rapid Prototype for Instrument Housing