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Overview of a Capstone Project Prerequisite Course*

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This paper describes a junior-level course at Texas A&M University that serves as the prerequisite to a capstone project course for seniors. It discusses the topics covered including laboratory exercises. In addition, the term project is discussed to illustrate the practice that it provides students in conducting a project.

COURSE DESCRIPTION

IN THIS course, students build upon their prerequisite knowledge of microprocessor hardware, assembly language programming, software development and system integration concepts. The course progresses from advanced studies of I/O techniques for microprocessors to standard bus systems, which are used to implement industrial control systems.

Technologists entering industry must be competent in the implementation of computer hardware and software components. They must also be capable of working with stand-alone computer systems. In addition, the use of the computer as a tool in the design process is important. It is the intent of this course to provide further educational experiences to reinforce these concepts and to provide the experience of a team project. The activities involved in the team project introduce the procedures to be followed in the senior project course.

An example project assignment is provided in the Appendix. It illustrates the information given to students early in the semester regarding the upcoming project. This allows students to be better prepared by researching the technology and topics that will be required.

HARDWARE TOPICS

A range of computer peripheral control circuits are studied. The devices represent most of the types of input and output interfaces used in microcomputer systems today. The student is required to interface to the peripheral integrated circuits, initialize them with test software and analyze their operations under various setup conditions.

The use of various types of specialized test equipment is required to analyze the performance of interface and software designs. Table 1 lists the laboratory equipment available at each station for student use. The primary types of equipment that support these activities are digital oscilloscopes, microprocessor troubleshooters and logic analyzers. Signal timing is analyzed under dynamic as well as static conditions.

SOFTWARE TOPICS

A range of software is studied, providing students with an introduction to the design, development and use of data acquisition and control software. Table 2 lists the software available for use by students in the project assignment. The software competencies include the use of computers for generating and testing programs, assembly language programming for both microprocessor and computer applications, using high-level languages to develop control programs and mixed language programming techniques.

TERM PROJECT

The students in this course are required to complete a term project incorporating hardware and software design, culminating in a working

Table 1. Equipment list

386 PC compatible microcomputer
SDK-86 8086 microprocessor system development board
Fluke 9010 microsystem troubleshooter with 8086 POD
Fluke 1953A counter/timer
NCI LA48 PC based 25 Mhz logic analyzer
Hewlett Packard 54600A dual channel 100 Mhz digital oscilloscope
Hewlett Packard 3311A function generator
Hewlett Packard 3438A digital multimeter
Leader LPS152 dual output power supply
LaserJet Printer
Plotter

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Table 2. Software

LabWindows Virtual instrumentation software
Pspice circuit simulation program
SDK-86 PC communications software
Borland Turbo C++ program development software
Borland Turbo Assembler program development software
Borland Turbo Linker program development software
WordPerfect 5.1 wordprocessor program
Harvard Graphics graphics/presentation program
Quattro Pro spreadsheet program
TK Solver mathematics program
Orcad schematic capture program

prototype. The class is divided into project teams by pairing individuals randomly. In addition to the final report, interim project documentation is required. The overall project grade is dependent on meeting milestones as well as the quality of the final prototype and report.

The project is designed to accomplish a variety of objectives that have been chosen to prepare students for the more intensive senior project that follows. The primary objectives are to provide learning experiences relative to most of the components of a senior project. Table 3 is a list of those experiences.

Table 3. Project experiences

- hardware design experience
- software design experience
- using software design tools
- using specialized system analysis equipment
- integration of hardware and software subsystems
- scheduling of project activities
- working in teams
- meeting deadlines and goals
- preparing project documentation
- demonstration and check-off of working prototype
- oral and written presentations of the design.

A timetable is presented to the students at the beginning of the semester making them aware of the deadlines related to the project. It should be noted that other laboratory assignments are still being conducted at the same time but with weekly timetables. The first of several required interim project documents are due, beginning with the ninth week. This allows the instructor to provide feedback on the quality of the documents and the project in time for the students to take corrective action. The timescale for the project is provided in Table 4.

In industry, many projects are not always completely finished on the projected schedule. It is brought to the attention of the students the importance of the test plan and check-off list where the percentage of completion and degree of meeting specifications can be assessed. The method and equipment used to demonstrate the various components of the system must be documented in the test plan. Bonus points may be earned by early completion of the project. These points are attached to the overall course average, and are thus significant. Of course, late penalty points may be assessed as well.

One final element included in the evaluation and assignment of grades for the project is the requirement for self-evaluations by each team. The evaluations are both in regards to their own performance as well as that of their partner.

Table 4. Project schedule of due dates

WEEK	ACTIVITY
9	Submit a memorandum presenting a brief overview of the project, identifying the team members and discussing their qualifications for the project. To be included with the memorandum is a project timeline for accomplishment of the project tasks and a preliminary hardware block diagram. Deviations from the original specifications must be justified and approval requested at this stage.
10	A memorandum providing an overview of the software design including flowchart and/or pseudo code must be submitted for approval.
12	The detailed hardware schematic is due.
13	A test procedure and check-off list for demonstration and acceptance of the system is due. In addition, a reference list showing the resources consulted for the project must be submitted using the correct bibliographic format.
14	The system prototype is demonstrated with check-off of all features relevant to the specifications performed. The instructor will evaluate the teams knowledge of the system by requiring oral responses to questions about the project.
15	A final project report is due. The format to be used is the IEEE Style. All work must be computer generated.

CONCLUSION

The approach taken in our program is not to wait until students are in a senior project or capstone course to introduce them to the activities required to complete a project. The technical requirements of a senior project are usually more substantial and require more effort to complete. The faculty have observed that as a result of this course, students have a better knowledge of the processes required to complete a project. It provides an introduction to all the issues required for the completion of a project, and allows the students to direct their attention towards the technical requirements of their senior project. The result has been a higher quality of senior projects with greater accomplishments and completion ratios.

APPENDIX: COURSE PROJECT HANDOUT

TO: ENTC 359 STUDENTS

COPY: LABORATORY TEACHING ASSISTANTS

SUBJECT: ENTC 359 SEMESTER PROJECT

PURPOSE OF PROJECT

One requirement of this course is the completion of a semester project. There are several reasons why this project is assigned at this time. One is to prepare students for more demanding projects later. Another is to provide students the opportunity to learn more about:

a. hardware design

b. software design

c. integration of software and hardware

d. prototyping and design testing

e. use of computer aided design tools

f. scheduling of project activities

g. meeting deadlines and goals

h. preparing project documentation

i. demonstration and delivery of the system.

PROJECT SPECIFICATIONS

The minimum specifications for this project are:

a. 3 Intel 8254 timer outputs will be connected as Intel 8259 PIC interrupts and used to sequence the reading of analog inputs

b. 3 analog inputs will be monitored: temperature (LM354 or equiv.); variable voltage from a potentiometer (0 - 10VDC); and linear ramp voltage from (0 - 5VDC)

c. the analog to digital conversion will utilize an ADC-0808 integrated circuit that is under control of the SDK86 single board computer

d. the ADC-0808 EOC signal will be used as an interrupt causing the SDK86 to read the digitized value of the converter

e. the ramp voltage will be under the control of the SDK86 and designed to run only during the time it is being monitored by the ADC0808

f. the temperature and potentiometer voltage readings will be displayed on the SDK86 display

g. ramp voltage readings will be displayed on the screen of a PC which receives the ramp data by RS-232 data link through the SDK86 serial port

MILESTONE DATES

Milestone dates are as follows:

a. Mar. 16
   - hardware block diagram and description
   - memorandum accepting project with a timeline for completion

b. Mar. 23
   - software flowchart/pseudocode and description

c. Apr. 6
   - detailed schematic diagram

d. Apr. 20
   - test procedure
   - checkoff guide

e. Apr. 20
   - reference list

f. May 5
   - demonstration of project
   - final project report.

REQUIREMENTS FOR SUBMISSIONS

The documents specified above will be prepared according to the IEEE Style. All items will be computer generated. This will require the use of a word processor, computer aided drafting program, schematic capture program, software generation program, etc. Work will be submitted as generated on printers or plotters.

EVALUATION OF WORK

Items detailed in a through e above will count as homework grades. Late documents will be evaluated but no homework grades given. Item f will be the overall project grade as shown in the syllabus. You will be expected to be able to answer questions about your design during its demonstration and checkoff.

BONUS/PENALTY POINTS

Bonus points may be earned by early completion of the project. Two bonus points per week (maximum of 6) may be earned for early completion of the project. The points for early completion of the project will be applied to the final exam grade. The deadlines for the early completion points are:

April 14	6 pts
April 21	4 pts
April 28	2 pts

Late project completions are subject to the normal laboratory penalties. Projects are not complete until a report has been submitted. No incomplete course grades will be given due to a late or missing project.

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