# Senior Design Project: Undergraduate Thesis

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***Abstract*—Engineering design has become a critical element of the undergraduate engineering curriculum. To become accredited by the Accreditation Board for Engineering and Technology (ABET) requires that at least 24 credits of design content be included in the four-year undergraduate engineering curriculum. Senior design is the principal course in which students apply their knowledge in several disciplines to one project assignment and is a significant step towards meeting ABET requirements. Engineering experience acquired in the senior design course is a valuable aid to students as they learn how to apply theory to an actual design project. The senior design course develops project management and oral and written communication skills and enables students to learn scheduling, team coordination and cooperation, parts ordering, and cost/performance trade-offs. Ten senior design projects that have won IEEE and SME student paper contests are presented herein as a guide in the difficult selection of suitable design topics. The unique nature of the senior design course requires certain departures from usual engineering course organization if students are to derive the maximum benefit. Senior design is nearly equivalent to an industrial internship and may be more valuable as the first step a student takes in making the transition to working engineer.**

## I. Introduction

LABORATORIES which are focused on experimental work in areas such as circuits, electronics, control, communications, and logic design are components of most electrical engineering curricula. Senior design is a course that uniquely combines and directs both laboratory and classroom knowledge in several subjects towards one application with the distinct purpose of helping students to understand how to apply classroom theory to real engineering problems. The undergraduate senior design project is comparable to a bachelors-level thesis and similar in individual time commitment to a graduate-level M.S. thesis, except that projects are carried out by a group of two or three students. Careful organization and close monitoring, as well as technical assistance by the faculty, are necessary if students are to realize the greatest possible benefit from the design course. Design projects selected must be within the students' skill level and be achievable in the time allowed, offer a design experience which is worthwhile for students and an adequate challenge to the students' creativity. This paper provides an outline and requirements for the senior design course and some examples of successful student design projects.

## II. Course Organization and Requirements

The structure, organization, and policies implemented in the senior design course evolved over a period of several years, through a continuing process of trial and revision by the entire electrical engineering department faculty.

1) Students are required to finish their senior design project in one academic year. The course is subdivided into three courses for the quarter system or two courses for the semester system. Course sequences can start in any quarter or semester and continue through two more quarters or one semester. Summer quarter or semester is not included in the normal sequence, but may be used for preparation in advance of the design course, or for finishing projects which are behind schedule.
2) Students must take the senior design project during their senior year. Because of the breadth and demanding nature of senior design, it is essential to have certain fundamental courses completed before students start their senior design project. Prerequisite requirements, such as circuits, electronics, logic design, and microprocessors, prevent students from taking senior design before their senior year.
3) Senior design projects are intended to be group projects, so that students learn how to work as an engineering team. Design groups may have two or three students. Groups of four or more students usually are too large to work efficiently or to be easily managed and may not provide sufficient design experience for all students in the group. Senior design projects are often too difficult for any student who is working alone. The very valuable experience of working in a design group is lacking in a one-student project.
4) Projects are supervised by the senior design committee, consisting of the project faculty advisor and two other faculty members. Students are expected to organize their own design group, consisting of their student coworkers. The project faculty advisor is chosen by the students and the remaining faculty committee members are then assigned to the student design group by the professor who is in charge of the course for the quarter or semester.
5) Early in the beginning quarter or semester, the design team meets with the faculty committee for review and approval of the initial design concept, the written project plan and an essential detailed schedule for completion of the project. Throughout the year, the design group must meet with the project advisor weekly and with the committee at the end of each quarter or semester to present a design review and progress report.
6) In addition to meeting with the advisor each week, students are required to attend a weekly senior design class meeting. In the first quarter or semester, each group

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makes an oral presentation describing their project to the entire design class.

At the end of each quarter or semester, each design group gives a progress report in which all group members participate. Remaining class periods may be scheduled for guest speakers on topics, such as engineering ethics, occupational safety and health, professional registration, resume writing, interviewing, job search strategies, and technical engineering presentations by practicing engineers from industry.

7) Each design group is required to keep a design notebook and activity diary throughout the year. The notebook must record daily progress on the project and any schedule revisions. The design notebook and activity diary are compatible with industrial practices and are important aids to the faculty committee in measuring project progress, and in making individual grade decisions.
8) A final, cooperatively-written report is required from each design group. These reports are archived in the department library for future reference and may serve as useful aids to future student design groups.
9) Design groups are expected to complete their projects by the end of the third quarter or second semester. A project may be extended into another quarter or semester only under extenuating circumstances, and with approval of the faculty committee, or department faculty in some instances. Students who are granted an extension are required to register for senior design project during the following quarter or semester, pay fees, and attend classes. A project may not be extended for more than one quarter or semester. If the project is not completed in the fourth quarter, or third semester, a new project must be initiated by the design group.
10) In consultation with the design group's faculty committee, the project advisor must give a letter grade to each student at the end of each quarter or semester. Incomplete letter grades are not permitted, since this may encourage students to procrastinate on project efforts until the last quarter or semester, when it usually becomes impossible to finish the project on schedule.

## III. Senior Design Project Abstracts

Senior design projects carried out by St. Cloud State University electrical engineering students have won IEEE student paper contests at both local and regional levels. The following are abstracts of some winning senior design projects selected for this paper.

### *A. A Video Digitizer Using TMS320C25 DSP For Image Enhancement [1]*

The goal of this project was the design and construction of a low-cost video digitizer and processing system for real-time industrial applications, such as non-destructive testing. This easily operated stand-alone device had standard 525-line monochrome input and output. An Intel 80186 microprocessor controlled the user interface, image capture and display on a personal computer (PC-AT). The digitizer captured both interlaced video fields using a TMS320C25 digital signal processor to perform high-speed image enhancement algorithms on the digitized image, yielding a 482-line image with 525 8-bit pixels per line.

### *B. GPIB Interface System [2]*

This project involved design, development and construction of a general purpose interface bus (GPIB) system, which connected directly into an 8-bit I/O expansion slot in a PC XT/AT computer. A standard IEEE-488 connector to IEEE-488 GPIB cable allowed an orderly and reliable means to control and exchange digital data with up to 14 instrumentation devices. The system included a software driver to provide a GPIB interface with high-level commands (e.g., REMOTE, LOCAL, SEND, RECEIVE). A software driver permitted the user to write a control program in C language, and to call various GPIB functions to perform desired operations.

### *C. Parallel Processing Using INMOS T212 Transputer [3]*

This project consisted of design and construction of a parallel processing system using a 16-bit INMOS Transputer and the OCCAM programming language. Four transputers were interconnected through high-speed data links to a transputer development system contained in a personal computer (PC-AT). The transputer network was used to run an OCCAM language application program to demonstrate the speed advantages of parallel processing.

### *D. Microcontroller-Based Amateur Radio Satellite Tracking System [4]*

An Intel 8097 microcontroller-based system to track and facilitate communication with two amateur radio satellites was designed and constructed. The system controlled both uplink and downlink antennas while providing information on possible need for signal amplification and frequency shifting. This system allowed menu selection of operating options, and interfaced the microcontroller with a key pad, rotator controllers, and an LCD screen for information display. Hand calculation of satellite positions and trajectories is tedious and time-consuming. This tracking unit allowed amateur radio operators with limited radio satellite experience to communicate by means of satellites, thus increasing geographic area coverage.

### *E. High Speed Data Coprocessor For PC-AT Computer UsingTMS320C30 [5]*

The objective of this project was to design and construct a digital signal processing card for a PC-XT/AT using a TMS320C30 digital signal processor. The processor performed fast Fourier transforms and other signal processing routines on a $128 \times 128$ pixel image in a fraction of the time needed to implement these operations with only a PC. A PC controlled all processes on the expansion card, extracting a block of data from a stored image, and writing this data directly to memory on the expansion card. The TMS320C30 was enabled to read this image data, perform an FFT on the data, and store the

FFT data in memory. The PC retrieved the processed data from the expansion card memory and stored the FFT results on a hard disk.

### *F. An X-Window Interface For An IBM SCARA Robot [6]*

This project created an $X$-Window Interface for an IBM 7545 selective compliance assembly robot arm (SCARA) robot. This user interface provided two major functions: (1) Control panel simulation; and (2) teach mode. Control panel simulation enabled the user to manipulate the robot arm using a graphical representation of the control panel and mouse. Teach mode allowed the user to step the robot through a series of motions, store these movements in a file, and then execute a control program.

### *G. Microprocessor-Controlled Security System [7]*

For this project a user-friendly residential or commercial microprocessor-based security system was designed. The Intel 8051 system was completely self-contained, could be customized by the user, and was capable of monitoring eight zones of eight sensors each, for a total of 64 sensors. The system provided up to 16 outputs, which could be driven by any particular sensor, although groups of sensors typically were chosen to drive groups of outputs. Additional sensors and output modules could be added by including additional hardware and modifying the software. The protection mode was selectable by arming particular sets of sensors and outputs, and a default protection mode was also provided by the system.

### *H. Multi-Axis Robotic Motor Controller [8]*

A controller was designed for six DC motors mounted in a Mentor Robot to have the capability of changing motor compensators and sampling frequency. The control board used a TMS320C25 to implement digital compensators and enable change of compensation through a PC interface. Two major components provided both macro- and micro-control. The macro-control system used the PC graphical user interface and the TMS370C756 microcontroller for I/O handshaking to support user interaction. The micro-control system used the Mentor Robot's individual motor compensators, the TMS320C25, A/D and D/A converters, and other components such as memory and communication interface.

### *I. Neural Network Implementation for IBM NNU/2 with High-Speed Digital Signal Processor [9]*

The objective of this project was to improve the training speed for IBM's neural network utility, NNU/2. A modified back propagation algorithm was implemented on the Texas Instruments TMS320C30 digital signal processor. The speed of the neural network was also increased by development of a conjugate gradient algorithm with the TMS320C30.

### *J. Digital Signal Processor-Assisted Image Processing Optimized for Two-Dimensional Fast Fourier Transform [10]*

A low-cost digital signal image processor was designed and constructed for the University's Physics Department. The DSP expansion card was installed in an IBM-compatible 80486 computer to perform optical spectrometer image data processing. The project included development of algorithms for extraction of two-dimensional sections of the optical image, data conversion and image rotation. PC expanded memory was used to store large image arrays in continuous data blocks.

## IV. Conclusion

The senior design project in engineering has become a critical phase of an undergraduate engineering student's training and education. With careful organization, the senior design project can be the most important course in the engineering curriculum. A broad range of topics for design can be found among many engineering disciplines. Cooperative design projects with other departments in a university and with industry are possible. Trade journals, such as *Byte* and *Computer Applications*, as well as the IEEE professional journals, may be sources for project topics. Since the course schedule, rules and requirements for senior design tend to be adaptable, these factors can be modified to suit the structure of a particular department. Although senior design calls for a considerable time commitment by both students and faculty, this course makes a significant contribution towards providing industry with engineering graduates who are well-prepared to assume responsible and productive engineering assignments, with less need for on-the-job training.

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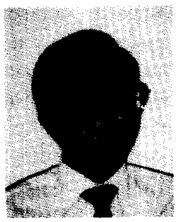

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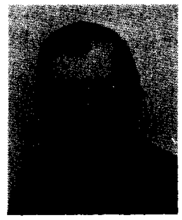

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