Microprocessor Course Design at
the FAMU/FSU College of Engineering

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ABSTRACT
Microprocessor-based system design has become an increasingly important subject of all engineering disciplines in recent years. Applications cover a wide range of areas, including signal processing, control systems, communications, microcomputers, robotics, etc. This paper describes the microprocessor course design currently under development in the Department of Electrical Engineering at the FAMU/FSU College of Engineering (a joint program of the Florida A&M University and the Florida State University).

Introduction
The design of digital systems using microprocessors, instead of other types of LSI/VLSI digital integrated circuits, has increasingly become the technique of choice for numerous applications. In many cases, microprocessor-based systems are more reliable, less expensive, easier to debug, easier to maintain, and easier to upgrade and enhance than their hardwired-logic counterparts. And with the newer generation of microprocessors currently becoming available, even the speed gap between approaches has been reduced. With these premises in mind, the microprocessor course design sequence is being assembled in order to develop a well-rounded coverage of this important area, stressing both software and hardware considerations.

Course Goals and Philosophy
A number of goals have been outlined in the evolution of the microprocessor course sequence in the Electrical Engineering Department. Among these, some of the most important include:
- Hardware and Software Issues
- System, Program, and Interface Design
- Experience with both of the major microprocessor families (68000 and 8086)
- Industry-like design project experience with a microprocessor-based system project

To achieve these goals, it became clear that at least a two course sequence was called for. After this realization, it became necessary to establish some form of priorities with respect to course coverage. The need for balance in software and hardware coverage was recognized. In addition, discussion of design would need to include system design, interface design, as well as program design. This relationship is graphically portrayed in Figure 1.

Implementation Phases
The first phase of the implementation was in place until early 1988 and consisted of a single senior-level microprocessor course offered as an EE technical elective entitled EEL-4930 Special Topics: Microprocessor Applications. This course concentrated on the Intel 8085 microprocessor and used the text "Microcomputers and Microprocessors" by John Uffenbeck.

Lab assignments took place on DEGEM 8085 trainer systems, and included such topics as arithmetic and logical operations, searching, array manipulation, sorting, subroutines, A/D, D/A, and timers.

The second phase began in early 1988 with a single senior-level microprocessor course offering as a required course for all EE majors entitled EEL-4746 Microprocessor-Based System Design. This course concentrates on the Intel 8086 and 8088 microprocessors. A sample course outline is included below:

Texts:

Prerequisites: Digital Electronics; Fortran and/or Pascal programming.

Course Description: This course serves as an introduction to system design with microprocessors, including microprocessor architecture, addressing, programming, and interfacing.

Course Objective: The student will acquire the knowledge of the basic software and hardware concepts necessary for the design, construction, operation, programming, and interfacing of microprocessor based systems. This knowledge will be demonstrated in the design laboratory and with programming assignments on the 8086 family of microprocessors.
**Course Outline:**

Chapter 1. Preliminary Considerations
Chapter 2. The Microprocessor
Chapter 3. Practical Microprocessors
Chapter 4. Programming a Microprocessor System
Chapter 5. Interfacing with the Microprocessor
Chapter 6. Design of Microprocessor Systems

Upon reviewing different 8086/8088 based textbooks available, the more software oriented text "Microcomputer Systems: The 8086/8088 Family" by Liu and Gibson was initially chosen and used. However, as this and other textbooks in this area seem to rarely cover both hardware and software issues in equal depth, coupled with the realization that software texts are readily available in this area at any bookstore (thanks to the success of the IBM-PC), it became clear that a hardware oriented textbook with software oriented handouts would be more appropriate. Thus the more hardware oriented text "Microprocessor-Based System Design" by Comer is now currently used along with supplemental handouts as needed. In addition, the lab text "Microcomputer Experimentation with the Intel SDK-86" by Leventhal is incorporated.

Software oriented class programming assignments take place using Samsung and Zenith personal computers along with the Microsoft Macro Assembler V5.1, and hardware interfacing oriented lab assignments take place on Intel SDK-86 single board computers. Class programming assignments are given to help the student better master 8086/8088 assembly language programming, as well as to introduce application tasks such as:

- arithmetic operations
- looping and program control
- searching
- sorting
- subroutines
- ASCII input/output
- array handling
- code conversions

SDK-86 lab assignments are more hardware interfacing oriented, and include such topics as:

- basic operations
- writing and running simple programs
- simple input and output
- processing data inputs, outputs, and arrays
- input/output using handshaking
- interrupts
- timing methods
- serial input/output
- microprocessor timing and control
- A/D and D/A

Finally, the third phase, which is currently underway, consists of a two course sequence. The first is the same senior-level course included in phase 2. The second however is a new senior-level course, entitled EEL-4748 Embedded Microprocessor Design Project, and can be used by EE students to fulfill either a design project requirement or as an EE technical elective with design content. A sample course outline is included below:

**Texts:**


**Prerequisites:** EEL-4746 (Microprocessor-Based System Design with lab)

**Catalog Description:**
Projects will be selected with consent of instructor. Project support will consist of formal lectures and an "open-door" Motorola 68000 laboratory.

**Course Objective:**
Students will work individually or in small groups in the development of a microprocessor-based system using the Motorola 68000 microprocessor development equipment in the department. The design will include both hardware and software design components. The steps in the design process of this system will include the following:

- Define requirements
- Develop Specifications
- Preliminary Design
- Intermediate Design
- Detailed Design
- Implementation
- Verification and Acceptance

After a short period of time of lecture on microprocessor-based system design as it pertains to the MC68000, the format of this new course will parallel that of a project team in industry. The instructor will act as project leader, and the students will form the project teams. Students will be expected to progress with little direct supervision, and will be required to present their preliminary and final designs to the project leader and the other project teams at critical milestones in the design process.

**Design Project Criteria:**
The student will choose a design project subject to the approval of the instructor. The project chosen must meet the following requirements:

1) Must be of sufficient design complexity and length to satisfy a full three semester-hour level of effort
2) Must consist of both hardware and software components
3) Must incorporate a MC68000 family microprocessor.

Possible platforms include:

- Apple MAC computers (MacPlus and SE)
- Motorola MC68000 Educational Computer Boards (ECBs)
- AT&T Unix PCs (M68010-based)
- MC68000-based system built from scratch (prototype)
- Your own equipment (if you have a computer with an MC68001 in it)

**Multiple-member Project Teams:**
Multiple-member project teams will be allowed only if, in the instructor's judgement, each member's part meets the design project requirements by itself, and the delineation of responsibilities is such that individual grading is possible.

**Tentative Meeting Outline:**
A. Overview of the MC68000 and departmental equipment [2-3 weeks]
B. Preliminary Design Review (Requirements through Preliminary Design) [1-2 weeks]
C. Consulting and discussion [8-11 weeks]
D. Critical Design Review (thru Acceptance and Verification) [1-2 weeks]

Design Project Report:
Each student will submit a completed design project report before final's week at the end of the semester, which should contain documentation on each of the design phases carried out in the project (requirements definition through acceptance and verification). This report should be double-spaced using a word-processor (with a spelling checker).

Course Placement in the EE Program:
This course can be used as a substitute for a design project (EEL-4914) or as an EE technical elective with design content (see your advisor for details).

As can be seen from the course outline, there are no prescribed lab assignments in EEL-4746C. Instead, all of the research, design, implementation, etc. is completely left to the project team member (i.e. the student). Every effort is made to make this endeavor as industry-like as possible, so as to better prepare the students for scenarios similar to those they may encounter in the future.

Plans for the Future
Current considerations for future expansion in EEL-4746 can be categorized into two groups: system design experience, and advanced microprocessors in the 8086 family.

To begin with, the ability to achieve a level of hands-on experience with microprocessor design from the system design level would be useful. However, with a general purpose microprocessor like the 8086 or 8088, this can be a full semester project in and of itself. Thus, it is currently impractical to have the students do system design work in the lab. However, due to the availability of the 8051 family of microcontrollers, coupled with the fact that the current text discusses the 8051 family, the possibility of a short (perhaps 2-3 week) system design project using a member of the 8051 family is being considered. If adopted, this project would in all likelihood come as a final lab project near the end of the semester. The proposed migration of microprocessor coverage is shown in Figure 2.

![Figure 2. Migration Underway in Coverage](image)

In addition, if time permits, it may be advantageous to provide the student with a short introduction to the more advanced microprocessors in the 8086 family, including the 80286 and 80386. For example, near the end of the semester of EEL-4746 when the students have gained significant proficiency with the 8086/8088, it would be possible to carry their knowledge one step further with this discussion. And in fact, should the funds be available, consideration has been given to the possibility of having EEL-4746 buy 80286 or even 80386 equipment at some point in the future.

Conclusions
The area of microprocessors and microprocessor-based system design is an essential one in any electrical engineering curriculum. As such, the coverage of the issues involved must include both hardware and software considerations. This should be clear, as it is the programmable nature of the microprocessor that makes it such a useful digital design device; and consideration of the hardware issues (and interfacing to the outside world) is required if the microprocessor is to perform useful functions.

To achieve the level of understanding and experience required, hands-on assignments are essential. Programming proficiency at the assembly language level can ONLY be gained with practice. And, at the same time, system and interfacing design issues covered in the lecture need to be reinforced in the laboratory. Not only does 'multiple exposure work', but when carried out in different manners, it works more effectively.

Finally, the FAMUIFSU microprocessor course sequence has been, and continues to be, optimally formulated to prepare the students for real-world applications. This formulation is supported by the coverage of hardware and software issues, design project experience, and the treatment of the two predominant microprocessor families (8086 and 68000). It is these considerations which help to cover the vast majority of current and projected applications.

REFERENCES