Overview

This course offers a global perspective on the design of a full processor taking logic gates as the simplest building blocks. The course begins with the design of simple combinational and sequential circuits, continues with the definition of a custom instruction set architecture (ISA), and wraps up with the construction of the hardware that implements this ISA.

The course lectures are accompanied by lab sessions that guide the student through an incremental design of a fully functional single-cycle processor data path. All design steps are synthesized into the FPGA of a ZedBoard, an integrated system-on-chip based on an ARM processor.

Prerequisites

Course EECE 2160 Embedded Design Enabling Robotics is a prerequisite for this course. In particular, the student is assumed to have internalized all of the digital logic design material presented in this prerequisite course. The student must be familiar with Boolean algebra, basic combinational logic design (adders, subtractors, decoders, encoders, multiplexers), and basic sequential logic design (latches, flip-flops, finite-state machines).
Textbooks

The core material presented in this course is extracted from the following textbook, though the order of concepts will differ. Even though this book is a good reference material for you, all of the material given during lectures and on Blackboard will be self-contained.


Grading

<table>
<thead>
<tr>
<th>Component</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Homework</td>
<td>20%</td>
</tr>
<tr>
<td>Quizzes</td>
<td>20%</td>
</tr>
<tr>
<td>Midterm exam</td>
<td>20%</td>
</tr>
<tr>
<td>Final exam</td>
<td>40%</td>
</tr>
</tbody>
</table>

Homework assignments

There will be a total of 10 weekly homework assignments. Assignments will be posted on Blackboard at least 7 days before their due date, and must be submitted on Blackboard as well. Each homework assignment will require you to upload a PDF file with your answers, which you can produce from most common word editors (Microsoft Word, LibreOffice, LaTeX, …).

Homework due dates are strict deadlines with no exceptions, specified at the end of this document. Late homework will not be accepted under any circumstances. Please make sure that you submit your assignments in advance in order to avoid unexpected submission problems due to Internet connectivity issues, trouble with PDF document generation, etc.

To add some flexibility to this policy, the average grade for homework assignments will be calculated by discarding either that which received the lowest grade or which was not submitted on time at all. This exception is aimed at covering any inevitable situation that prevented you from submitting a homework assignment on time, while it also benefits those students with no missing assignment.

Midterm and final exams

A midterm exam will cover the first part of the course material. A comprehensive final exam will focus on the second part of the course, but will also include the material corresponding to the first part. The dates for both the midterm and the final exam will be announced at the beginning of the semester.
Quizzes
There will be a total of 4 quizzes during the semester, on the dates specified in the schedule at the end of this document. Quizzes will have an approximate duration of 20 minutes, and will start in the beginning of the lecture time.

Grade conversion
Your final grade is calculated as a numeric grade between 0 and 100 based on the percentages shown above, and then converted into a letter grade using the following scale:

<table>
<thead>
<tr>
<th>High</th>
<th>Low</th>
<th>Grade</th>
<th>High</th>
<th>Low</th>
<th>Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>95</td>
<td>A</td>
<td>69.99</td>
<td>66.66</td>
<td>D+</td>
</tr>
<tr>
<td>94.9</td>
<td>90</td>
<td>A-</td>
<td>66.65</td>
<td>63.33</td>
<td>D</td>
</tr>
<tr>
<td>89.99</td>
<td>86.66</td>
<td>B+</td>
<td>63.32</td>
<td>60</td>
<td>D-</td>
</tr>
<tr>
<td>86.65</td>
<td>83.33</td>
<td>B</td>
<td>59.99</td>
<td>0</td>
<td>F</td>
</tr>
<tr>
<td>83.32</td>
<td>80</td>
<td>B-</td>
<td></td>
<td></td>
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<td>79.99</td>
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<tr>
<td>73.32</td>
<td>70</td>
<td>C-</td>
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Attendance and Punctuality
While attendance to the lectures is highly recommended, punctuality in class is indispensable, and constitutes a basic rule of respect toward your instructor and classmates. If any particular reason forces you to come in late to class, please notify your instructor in advance.
Course Topics

The course is structured in two main parts, each covering the topics listed below (subject to change):

Part I – Digital Design

- Boolean algebra review, truth tables, logic gates, Boolean postulates and theorems
- Number representation review, base conversions, two's complement
- Combinational logic review, adders, subtractors, encoders, decoders, multiplexers
- The Verilog hardware description language, structural/dataflow/behavioral models, test-benches
- Sequential logic review, latches, flip-flops, registers, register files, read ports, write ports
- Shift registers, parallel load, control signals
- Synchronous counters, limited-range counters

Part II – Computer Organization

- Assembly language, logical registers, arithmetic-logic instructions, immediate operands, shift instructions, memory instructions, branches, instruction encoding
- Single-cycle processor, the datapath, control unit, performance analysis
- Multi-cycle datapath, multi-cycle control unit, performance analysis
- Pipelined datapath, pipeline control unit, performance analysis
- Advanced topics: data hazards, control hazards, pipeline bubbles, branch prediction, caching
Office Location

1) Find the office building at 140 The Fenway (TF), and enter the main door located at the parking lot.

![Office Location Diagram]

2) Take the main elevator to the 3rd floor.

3) Once on the 3rd floor, call me at 617-373-3895. My office is in a locked research laboratory. I will meet you on the hallway right by the elevator and let you in.
## Important Dates

<table>
<thead>
<tr>
<th>Week 1</th>
<th>9/6</th>
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</thead>
<tbody>
<tr>
<td>Week 2</td>
<td>9/13</td>
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</tbody>
</table>
| Week 3  | 9/20 | Wednesday 9/23 – Homework #1 due  
| Week 4  | 9/27 | Wednesday 9/30 – Homework #2 due  
|         |     | Thursday 10/1 – Quiz #1  
| Week 5  | 10/4 | Wednesday 10/7 – Homework #3 due  
| Week 6  | 10/11 | Wednesday 10/14 – Homework #4 due  
|         |     | Thursday 10/15 – Quiz #2  
| Week 7  | 10/18 | Wednesday 10/21 – Homework #5 due  
| Week 8  | 10/25 | Wednesday 10/28 – Homework #6 due  
|         |     | Thursday 10/29 – Midterm  
| Week 9  | 11/1 | Wednesday 11/4 – Homework #7 due  
| Week 10 | 11/8 | Thursday 11/12 – Quiz #3  
| Week 11 | 11/15 | Wednesday 11/18 – Homework #8 due  
| Week 12 | 11/22 | 11/25-11/28 Thanksgiving break  
| Week 13 | 11/29 | Wednesday 12/2 – Homework #9 due  
|         |     | Thursday 12/3 – Quiz #4  
| Week 14 | 12/6 | Wednesday 12/9 – Homework #10 due  
|         |     | 12/11 through 12/18: Final exams (exact date TBD)  