Introduction

Digital electronics are a key component of modern computing, communications, test and measurement equipment, and data acquisition instruments. Real world analog signals can be digitized and represented as a series of 0s and 1s called bits. Binary arithmetic and logic functions are applied to these bits to process/filter signals, make decisions based on the input, and output digital information. In this course you will learn about and investigate the fundamental functions performed by digital circuits. These functions are implemented electrically in devices called “chips”. Advances in technology have allowed engineers to program any number of combinations of these fundamental functions into miniaturized integrated circuits designed for specific applications.

Laboratory

The lab is critically important for students of electronics because it illustrates the difference between the idealized, theoretical world of textbooks and computer simulations and the practical, experimental world of building and debugging circuits which don’t behave as expected. Integrated circuits are manufactured to various “tolerances” and combinations chips at different points in the tolerance range can lead to unexpected behavior. Furthermore, the proper functioning of a chip can not be determined from its outward appearance. Add to this the presence of electrical noise and the possibility of loose/intermittent connections and you get a real idea of what is actually involved in creating a working electronic circuit. Revel in the problems you encounter and learn from your experiences. The critical thinking skills you develop in debugging and testing an electronic circuit can be applied to many other problems you will encounter in life.

Lab Schedule by cycle

1. Oscilloscope pre-lab exercise (on your own)
2. Basic TTL gates and combinational logic
3. Multiplexers, decoders, latches, flip-flops, switch bounce and tri-state logic
4. Synchronous and asynchronous counters
5. Shift registers and random sequences
6. Digital to analog and analog to digital conversion
7. Individual design project

Lab is scheduled at a formal time, but you may need to complete your lab on a different day. To that end, you will be assigned a protoboard on which to build your circuits. Your lab grade will be based on what you record in your Roaring Spring 5x5 quadrille ruled (or equivalent) lab notebook. Please be thorough, complete, and legible! Make sure to include a parts list at the beginning of each lab write-up which indicates actual chip numbers used (i.e., a quad NAND gate could be a 74LS00 chip or a /30001 military chip). You will probably need 2 of these lab notebooks (which may be “used”) since I will be grading completed labs while you are working on current labs. Labs are due 3 days after your scheduled lab period at the beginning of class. (If you are in the day 3 lab
they are due on day 6 at 8:00 am, if you are in the day 6 lab they are due on day 3 at 8:00 am.)

Homework

Homework includes both assigned reading and assigned problems. You are expected to complete the assigned reading before the date indicated (see detailed schedule on page 3). Work through the homework problems as you read the text.

Course Outline

**Cycle 1: Introduction and Combinational Logic**
- Day 1: preliminaries (on your own)
- Day 2: number codes, binary arithmetic, basic gates
- Day 4: logic levels, logic families, logic identities
- Day 6: Karnaugh maps, combinational devices

**Cycle 2: Sequential Logic – Flip-flops**
- Day 2: SR, D, and JK flip-flops
- Day 4: flip-flop applications
- Day 6: more flip-flop applications

**Cycle 3: Sequential Logic – Clocks and Counters**
- Day 2: 555 timer, voltage controlled oscillators, crystal oscillators
- Day 4: counters
- Day 6: counter applications

**Cycle 4: Sequential Logic – Shift Registers, Interconnection Methods**
- Day 2: shift registers, monostables
- Day 4: midterm exam
- Day 6: buffers, latches, transceivers, external loads and long wires

**Cycle 5: Digital Meets Analog**
- Day 2: analog-to-digital and digital-to-analog conversion
- Day 4: comparators and transducers
- Day 6: memory, microprocessors, and microcontrollers

**Cycle 6: Digital Filtering**
- Day 2: sampling and fourier series
- Day 4: IIR and FIR filters
- Day 6: final exam

Grading

Your grade for the course will be calculated as follows:

<table>
<thead>
<tr>
<th>Item</th>
<th>Percent</th>
<th>Due Date</th>
<th>Grading Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assigned Problems</td>
<td>15%</td>
<td>day 1 at noon</td>
<td>A 93-100</td>
</tr>
<tr>
<td>Midterm</td>
<td>17%</td>
<td>Thursday, September 29</td>
<td>AB 88-92</td>
</tr>
<tr>
<td>Labs</td>
<td>34%</td>
<td>day 6 or 3 at 8 am</td>
<td>B 83-87</td>
</tr>
<tr>
<td>Final</td>
<td>34%</td>
<td>Friday, October 21</td>
<td>BC 78-82</td>
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<td>F 0-59</td>
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</table>

Grading Scale

- A 93-100
- AB 88-92
- B 83-87
- CD 68-72
- C 73-77
- D 60-67
- F 0-59

Internet Resources

- [http://www.qsl.net/yo5ofh/data_sheets/data_sheets_page.htm](http://www.qsl.net/yo5ofh/data_sheets/data_sheets_page.htm) – pinouts and truth tables
- [http://www.datasheetcatalog.com/](http://www.datasheetcatalog.com/) – full datasheets including electrical characteristics
- [http://www.digikey.com/](http://www.digikey.com/) – Digi-Key is a supplier of electronics parts
- [http://www.newark.com/](http://www.newark.com/) – Newark Electronics is a larger electronics supplier
Detailed Schedule

Note the following definitions:
- **H** = Horowitz and Hill textbook
- **P** = additional problem set (separate handout)
- **EM** = [http://www.physics.csbsju.edu/217/electric_measurement.pdf](http://www.physics.csbsju.edu/217/electric_measurement.pdf)

“thru” and “-” mean through and including (i.e., a reading assignment of “H: 1.01-1.03” means read all three Horowitz & Hill sections, including, for example, 1.03).

Readings should be completed before the indicated date. Problems are due on day 1 of the following cycle by 12:00 pm (noon).

<table>
<thead>
<tr>
<th>Cycle.Day</th>
<th>Date</th>
<th>Reading</th>
<th>Problems</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>8/31</td>
<td>Preliminaries&lt;br&gt;H: 1.01-1.03, Appendix A&lt;br&gt;EM: 3.2.1, p. 8; #18-19, p. 15</td>
<td></td>
</tr>
<tr>
<td>1.2</td>
<td>9/1</td>
<td>Codes, binary math, basic gates&lt;br&gt;H: 8.01-8.04, 8.06-8.08&lt;br&gt;H: 8.2-8.4, 8.8-8.9; P: 1-2</td>
<td></td>
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<tr>
<td>1.4</td>
<td>9/5</td>
<td>Logic levels, logic families, logic identities&lt;br&gt;H: 8.10-8.12&lt;br&gt;H: 8.11-8.12</td>
<td></td>
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<tr>
<td>1.6</td>
<td>9/7</td>
<td>Karnaugh maps, combinational devices&lt;br&gt;H: 8.13-8.15&lt;br&gt;H: 8.13-8.15, 8.20, 8.21, P: 3-5</td>
<td></td>
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<tr>
<td>2.2</td>
<td>9/9</td>
<td>SR, D, and JK flip-flops&lt;br&gt;H: 8.16-8.17&lt;br&gt;P: 6-10&lt;br&gt;H: 8.24, 8.25</td>
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<tr>
<td>2.4</td>
<td>9/13</td>
<td>Flip-flop applications&lt;br&gt;H: 8.18-8.19&lt;br&gt;H: 8.20-8.23&lt;br&gt;P: 11, 12</td>
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<tr>
<td>2.6</td>
<td>9/15</td>
<td>More flip-flop applications&lt;br&gt;H: 8.20-8.23&lt;br&gt;H: 5.8, 5.9</td>
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<tr>
<td>3.2</td>
<td>9/19</td>
<td>Timers and oscillators&lt;br&gt;H: 5.14-5.15, 5.19&lt;br&gt;H: 8.35-8.37</td>
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<td>3.4</td>
<td>9/21</td>
<td>Counters&lt;br&gt;H: 8.25, 8.29&lt;br&gt;H: 8.33-8.35</td>
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<td>3.6</td>
<td>9/23</td>
<td>Counter applications&lt;br&gt;H: 8.24, 8.26-8.28, 8.20-8.23</td>
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<td>4.4</td>
<td>9/29</td>
<td>Midterm Exam&lt;br&gt;Buffers, latches, transceivers, loads and long wires&lt;br&gt;H: 9.08, 9.11-9.14</td>
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<td>4.6</td>
<td>10/3</td>
<td>A/D and D/A conversion&lt;br&gt;H: 9.15-9.23&lt;br&gt;H: 9.2-9.4</td>
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<td>5.2</td>
<td>10/5</td>
<td>Comparators and transducers&lt;br&gt;H: 4.23-4.24, 9.05-9.07, 15.01-15.08&lt;br&gt;P: 14, 15</td>
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<tr>
<td>5.6</td>
<td>10/11</td>
<td>Memory, μP, and μC&lt;br&gt;H: 11.01-11.04, 11.12</td>
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<td>6.2</td>
<td>10/17</td>
<td>Sampling and fourier series&lt;br&gt; P: 16-18</td>
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<tr>
<td>6.4</td>
<td>10/19</td>
<td>IIR and FIR filters&lt;br&gt;H: 5.04-5.05</td>
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<tr>
<td>6.6</td>
<td>10/21</td>
<td>Final Exam</td>
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