EECS 42 Introduction to
Electronics for Computer
Science

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MW 3-4, 10 Evans
Plus Discussion Section

http://inst.EECS.Berkeley.EDU/~ee42/

Goals of EECS 42

• Provide an overview of electronics
  – Terminology
  – Organization of the field
• Provide career foundation cornerstones
  – Skills – circuit analysis
  – Performance estimates – what sets
    fundamental limits
  – Examples of modern and changing technology

Course Overview

EECS 42 – Electronics for Computer Science

Introduces “hardware” side of EECS

Course content : (Not precisely in this order)

- Basic Device and Circuit Ideas
- Digital Circuits and Logic Delays
- Physical realization/CMOS
- Performance limits of CMOS digital circuits

Example:

PULSE: Output is Rising exponential
  then Falling exponential

Example: Switch rises at t = 0, falls at t = 0.1, 1 or 10μsec. (Do 1μsec case)

Solution: for RC = 1μsec:

During the first rise V obeys:

\[ V(t) = V_r(1 - e^{-t/RC}) \]

Thus at t = 1μsec, rising voltage reaches

\[ V(1) = 3.16V \]
TIMING DIAGRAMS
Show transitions of variables vs time

Logic state
A, B, C

Note that \( \overline{B \cdot C} \) becomes valid two gate delays after \( B \) & \( C \) switch, because the invert function takes one delay and the NAND function a second.

No change at \( t = 3\tau \)

 Hint: Identify Stages

See the further examples of op-amp circuits in the reader

CASCADE OP-AMP CIRCUITS

How do you get started on finding \( V_{00} \)?

Hint: Identify Stages

\[ V_{\text{THEVENIN}} (\text{Open Load}) = 3.3 \text{ V} \]

\[ V_{\text{ مضاربة}} (200k\Omega \text{ Load}) = 3.3 \text{ V} \]

\[ V_{\text{مضاربة}} (200k\Omega \text{ Load}) = 3.3 \text{ V} \]

The propagation delay is 
two times longer than that for the inverter!

The Parallel Lab for EECS 42

Why Take EECS 43 (The first lab)

- Its fun (actually!)
- You will do better in EE42.
- If you take any later labs (like CS150, EE142) you will be much better prepared.
- You will learn a few skills and make a robot
Instructional Team

- Professor Andrew R. Neureuther, 510 Cory
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- Teaching Assistants: Great Person in CAD!
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Game Plan 01/22/03

Today:

- Signals, Analog and Digital
  Schwarz and Oldham : 1.1-1.2
- Monday 01/27/03
  - Electrical Quantities
    Schwarz and Oldham: 1.3-1.4
- Wednesday 01/29/03
  - Kirchhoff Laws
    Schwarz and Oldham: 2.1-2.2

Problem Set #1 - Out 1/22/03 - Due 1/27/03 2:30 in box near 275 Cory
Practice Skills needed for Electronics without Electronics
1.1 Flow; 1.2 Potential; 1.3 Truth Table; 1.4 Graphs

Analog versus Digital Electronics

- Most (but not all) observables are analog
  think of analog versus digital watches
- But the most convenient way to represent and
  transmit information electronically is digital
  think of audio recordings
- Analog/Digital and Digital/Analog conversion is
  essential (and nothing new)
  think of a piano keyboard

Analog Signals

- May have very physical relationship to information presented
- In the simplest, are direct waveforms of information vs time
- In more complex cases, may have information modulated on a
  carrier as in AM or FM radio

Analog signal (microphone voltage) representing piano key A (440 Hz).

50 microvolt 440 Hz signal
25 microvolt 440 Hz signal

Microphone voltage with normal key stroke
Microphone voltage with soft pedal

Analog signal representing piano A, but one octave below middle A (220 Hz)
Digital Signal Representations

Example: Possible digital representation for the sine wave signals, and highlighting our maximum possible 50µV sine wave

<table>
<thead>
<tr>
<th>Amplitude in µV</th>
<th>Binary representation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0000001</td>
</tr>
<tr>
<td>2</td>
<td>000010</td>
</tr>
<tr>
<td>3</td>
<td>?</td>
</tr>
<tr>
<td>4</td>
<td>00011</td>
</tr>
<tr>
<td>5</td>
<td>000100</td>
</tr>
<tr>
<td>etc.</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>001000</td>
</tr>
<tr>
<td>16</td>
<td>010000</td>
</tr>
<tr>
<td>32</td>
<td>100000</td>
</tr>
<tr>
<td>63</td>
<td>111111</td>
</tr>
</tbody>
</table>

So Why Digital?

(For example, why CDROM audio vs vinyl recordings?)

- Digital signals can be transmitted, received, amplified, and retransmitted with no degradation.
- Binary numbers are a natural method of expressing logical variables.
- Complex logical functions are easily expressed as binary functions (e.g., in control applications).
- Digital signals are easy to manipulate (as we shall see).
- With digital representation, we can achieve arbitrary levels of "dynamic range," that is, the ratio of the largest possible signal to the smallest than can be distinguished above the background noise.
- Digital information is easily and inexpensively stored (in Disk, CDROM, DVD, RAM, ROM, EPROM, etc.), again with arbitrary accuracy.
Are Voltages in a Digital Circuit “0’s” and “1’s” ?
(continued)

Clever encoding methods (as opposed to simple digital representation) can lead to cost, size, and performance advantages:

Example: Telephone Dialing
- 1950: “Pulse dialing” Six pulses represented 6, etc.
- Improvement: “Tone dialing” Each number represented by a combination of tones (tones that are within the limited frequency bandwidth of telephones).
- Analog modern technology: Uses combination of amplitude and phase modulation to represent digital information. This is done because the telephone lines are filtered to stop all frequencies above 2kHz. Sending simple pulses would limit us to a few Kbits/sec maximum.

So need a computer scientist know about electronics ?

(Impossible to answer, but…)

- Knowing something about physical nature of information (voltages and currents) can be useful in understanding what goes in and out of a computer, memory, radio, etc.
- Knowing something about the electronic devices (e.g. CMOS) can be useful in understanding the restrictions on size, weight and performance of working systems.
- Learning enough electronics to be able to carry out simple performance and power calculations can be useful understanding the limits of actual physical hardware.
- Folks who know both hardware and software are extremely valuable in product design. ($$$$$$)