CSC270 — Circuits

Week #3 — Spring 2019s

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Lab Reports
Overall: good!

Main guideline: report should be self-contained

Add pin numbers

Pre-process your scans/photos

- black and white for diagrams
- pin numbers
- crop

Answer all questions, try to figure out the answer before writing the lab!

Truth-table + diagram + photo + paragraph = enough
Lab #1: Logic Gates and Integrated Circuits

Introduction

This lab is targeted towards students who have not exposed to the Digital Kit before. It aims to give them an introduction the Kit then use the AND, OR, NOT and XOR gates to generate the truth table in order to prove a logical expression, and to build a two bit adder and three bit adder. It also aims to assist students use the input and output switches and LEDs on the Kit to figure out what function a mystery logic gate performs. The instructions on the lab can be found on:

Lab Reports
Feedback 2

Figure 10: Schematic of the 2-bit adder circuit.*

Figure 11: Breadboard diagram for the 2-bit adder wiring.**

*Circuit schematics created in Logicsim.

**Breadboard diagrams created in Fritzing.
Unanswered Questions...
Exercises

• Simplify the following functions using Karnaugh maps:
  
  \[
  f(a, b, c, d) = \sum (1, 2, 3)
  \]
  
  \[
  g(a, b, c, d) = \sum (1, 2, 3, 5, 6, 7, 8, 9, 10, 11, 15)
  \]
  
  \[
  h(a, b, c, d) = \prod (1, 2, 3, 4, 12, 13, 14, 15)
  \]
Group Work

• Look at how we dealt with the NAND gate, and figure out everything there is to say about the NOR gate.
Assume that you have many 3-bit adders. How would you build a 32-bit subtractor?
Crash Course in Electricity and Electronics
Zero Physics background expected!
Hydrodynamic Analogy

Resistance, Intensity, Difference in Potentials

Ohm's Law

Exercises: solving electrical circuits

Resistors

Diode

Transistor

Practical Circuits
Main Concepts:

*Difference in Potentials* vs. *Intensity*
An Analogy

Hoover Dam

http://www.history.com/topics/hoover-dam
An Analogy

Hoover Dam

http://www.history.com/topics/hoover-dam

Intensity

Difference in Potentials
An Analogy

Hoover Dam  http://www.history.com/topics/hoover-dam

Difference in Potentials

Resistance

Intensity
An Analogy

Hoover Dam

http://www.history.com/topics/hoover-dam

Difference in Potentials

Intensity = 0

Resistance
An Analogy

Hoover Dam

http://www.history.com/topics/hoover-dam

Difference in Potentials

Intensity
Outline

Hydrodynamic Analogy

Resistance, Intensity, Difference in Potentials

Ohm's Law

Exercises: solving electrical circuits

Resistors

Diode

Transistor

Practical Circuits
Observations

• Resistance \(\uparrow\) Intensity \(\downarrow\)
Observations

- Resistance $\rightarrow$ Intensity $\downarrow$
- Resistance $\propto$ Intensity 0
Observations

- Resistance $\nearrow$ Intensity $\searrow$
- Resistance $\infty$ Intensity 0
- High difference in potentials $\nearrow$ Intensity $\nearrow$
Observations

• Resistance → Intensity ↓

• Resistance $\propto$ Intensity 0

• High difference in potentials → Intensity ↑

• Low difference in potentials ↓ Intensity ↓
Observations

- Resistance $\nearrow$ Intensity $\searrow$
- Resistance $\propto$ Intensity 0
- High difference in potentials $\nearrow$ Intensity $\nearrow$
- Low difference in potentials $\searrow$ Intensity $\searrow$
Another Analogy
Another Analogy

Difference in Pressure
Another Analogy

No resistance in the pipe $\Rightarrow$ no difference in pressure
Another Analogy

Difference in Pressure

Resistance
Another Analogy

Difference in Pressure

Resistance
Observations

- Keeping Intensity constant,
  
  Resistance  \arrow{up}
  Difference in Potentials  \arrow{up}
Assumptions

- An electrical wire has no resistance
- A closed switch has no resistance
- An open switch has infinite resistance
- The current flowing in a closed-loop circuit is the same everywhere.
Outline

Hydrodynamic Analogy

Resistance, Intensity, Difference in Potentials

Ohm's Law

Exercises: solving electrical circuits

Resistors

Diode

Transistor

Practical Circuits
Ohm’s Law

Voltage = Resistance * Intensity

\[ V = R \cdot I \]
Ohm’s Law

Voltage = Resistance * Intensity

V = R . I

Volt | Ohm | Amp
---|---|---
V | Ω | A
Outline

Hydrodynamic Analogy

Resistance, Intensity, Difference in Potentials

Ohm's Law

Exercises: solving electrical circuits

Resistors

Diode

Transistor

Practical Circuits
What is I?

5V

V

voltage

Ground

R

1 KΩ
What are $I$, $I_1$, $I_2$?

$5V$

Ground

$1\ K\Omega$

$I_2$

$I_1$

$R_1$

$R_2$
What is I?

5V

+ -

Ground

R1 1 KΩ

R2 4 KΩ
We Stopped Here
Didn't solve it...
What are $V_1$, $V_2$?
What are $V_1$, $V_2$?
What is $I$?
Outline

Hydrodynamic Analogy

Resistance, Intensity, Difference in Potentials

Ohm's Law

Exercises: solving electrical circuits

Resistors

Diode

Transistor

Practical Circuits
What does R look like?
### Resistor Color Table

<table>
<thead>
<tr>
<th>1st Digit</th>
<th>2nd Digit</th>
<th>Multiplier</th>
<th>Tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>x 1 Ω</td>
<td>± 1%</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>x 10 Ω</td>
<td>± 2%</td>
</tr>
<tr>
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<td>2</td>
<td>x 100 Ω</td>
<td>± 5%</td>
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<td>± 5%</td>
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<tr>
<td>4</td>
<td>4</td>
<td>x 10 KΩ</td>
<td>± 5%</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
<td>x 100 KΩ</td>
<td>± 10%</td>
</tr>
<tr>
<td>6</td>
<td>6</td>
<td>x 1 MΩ</td>
<td>± 10%</td>
</tr>
<tr>
<td>7</td>
<td>7</td>
<td>x 0.1 Ω</td>
<td>± 10%</td>
</tr>
<tr>
<td>8</td>
<td>8</td>
<td>x 0.01 Ω</td>
<td>± 10%</td>
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<tr>
<td>9</td>
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62 Ω ± 5%
What values?

Resistor Color Table

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</table>
Simplification

5V

+ voltage

Ground

R 1 KΩ

I

Ground
Simplification

+5V

R
1 KΩ
How Does This Apply to Us?
How Does This Apply to Us?
How Does This Apply to Us?
How Does This Apply to Us?
What is $Y(a)$?
Outline

Hydrodynamic Analogy

Resistance, Intensity, Difference in Potentials

Ohm's Law

Exercises: solving electrical circuits

Resistors

Diode

Transistor

Practical Circuits
Meet The Diode
Diode = \textbf{semi}conductor

\begin{itemize}
\item[1.] a combining form borrowed from Latin, meaning “half,” freely prefixed to English words of any origin, now sometimes with the senses “partially,” “incompletely,” “somewhat”:
\textit{semiautomatic; semidetached; semimonthly; semisophisticated.}
\end{itemize}

http://dictionary.reference.com/browse/english
DIODE

RECTIFICATION

LIMITER

DIODE GATE

DIODE CLAMPS

TECHNICAL SUPPORT FROM
JOSE JOJI,
WESTGHATS TECHNOLOGIES LTD
Symbol

Diagram of a circuit including a diode labeled 'P' and 'N', and a resistor labeled R1 with a value of 1 KΩ.
Symbol

Light Emitting Diode (LED)
Outline

Hydrodynamic Analogy

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Exercises: solving electrical circuits

Resistors

Diode

Transistor

Practical Circuits
Meet the **Transistor**
Meet the Transistor

\textbf{Collector}

\textbf{Base}

\textbf{Emitter}
Symbol

2N2222

Collector
Base
Emitter
What is f(a)?
A Real TTL Circuit

A Real TTL Circuit

A Real TTL Circuit

A Real TTL Circuit

What is \( h(a,b) \)?
Outline

Hydrodynamic Analogy

Resistance, Intensity, Difference in Potentials

Ohm's Law

Exercises: solving electrical circuits

Resistors

Diode

Transistor

Practical Circuits
Practical Design Rules for Discrete Parts
Input Switch

1 KΩ
Logic Indicator
Logic Indicator

What’s a good value?
Logic Indicator

What's a good value?

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>VCC Supply Voltage</td>
<td>4.5</td>
<td>5.0</td>
<td>5.5</td>
<td>V</td>
</tr>
<tr>
<td>TA Operating Ambient Temp</td>
<td>0</td>
<td>25</td>
<td>25</td>
<td>°C</td>
</tr>
<tr>
<td>I0H Output Current — High</td>
<td>54</td>
<td>0</td>
<td>0</td>
<td>mA</td>
</tr>
<tr>
<td>IOL Output Current — Low</td>
<td>54</td>
<td>4.0</td>
<td>8.0</td>
<td>mA</td>
</tr>
</tbody>
</table>

R

D. Thiebaut, Computer Science, Smith College