CS 2461: Lab 2
Using Integrated Circuits to Build Logic Circuits
Using Multimeters

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CS 2461 Lab 2: Digital Logic

Recap last week
- Ohm's Law
- Building a simple circuit
  - Using Breadboard, LED, Resistors

Today:
- Using multimeters, preparing wires and using wire stripper, prepping power supply
- Intro to 7400 Series Logic chips and your lab kit
- Reading a datasheet
- Designing your first Digital Logic circuit

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Pop quiz!

1. What is Ohm's law?

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What is a Multimeter

Device used to measure

- Voltage
- Current
- Resistance

- Has two leads/ends to connect to the points in the circuit where you want to measure
- Has a dial to select what you want to measure (V,I,R)
- Why is it useful ? We want to test if a circuit is working correctly by checking if the value (0 or 1) is what we expected
  - Analogy with software testing – print out values of variables

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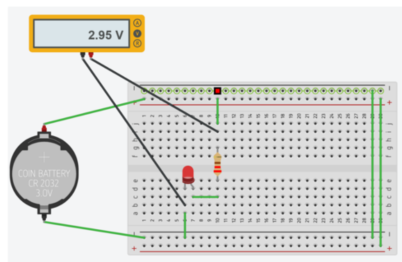
Using Multimeter to Measure Voltage

Measuring Voltage

- Set dial on multimeter to Volts
- Measure in parallel – touch ends to 2 point on a complete circuit and measure the voltage drop between those 2 points
  - The positive lead should be closer to power and negative lead should be closer to ground



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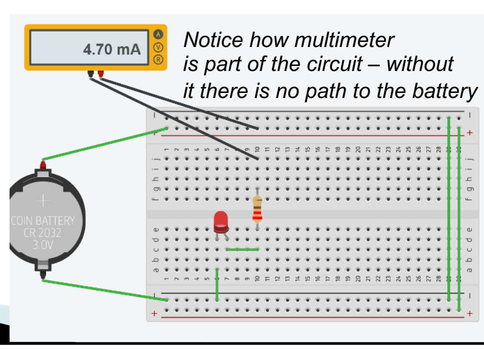
Using Multimeter to Measure Current

Measuring Current

- Set dial on multimeter to Amps
- Measure in series – the multimeter must be part of the circuit!
  - Again, be careful about positive and negative leads



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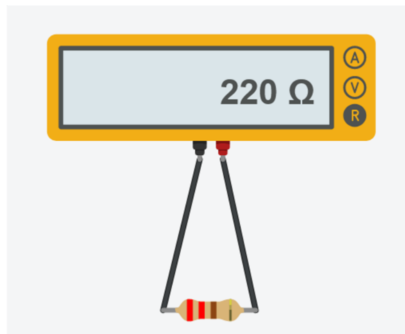
Using Multimeter to Measure Resistance

Measuring Resistance

- Set dial on multimeter to Ohms
- Measure a component (resistor, LED, etc.) on its own. No circuit needed. Touch the ends of the multimeter to either side of the resistor.



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Multimeter: Exercise

Experiment – Build/Use the circuit from the first lab

Connect to power

- Measure the voltage
- Measure the current
- Measure the resistance of the resistor and the LED
  - Change the resistor to a different value and see if the multimeter readings are different

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Building Digital Logic circuits

You will be designing logic circuits in this class

- Lectures: Cover theory of logic design, and build with discrete components (i.e., single gates) and use simulator (Cedar Logic)
- Labs: Build and test logic circuits using integrated circuits (Chips)

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Integrated Circuits

Combinational logic gates (and devices)

- AND, NOT, OR, ...
- Each built using several transistors

In practice, multiple gates are packaged into a single chip (Integrated Circuit – IC)

- Example: 7404 is an inverter chip with multiple inverters

An entire processor is packaged into a single chip

An IC is connected to other circuitry outside the chip by connecting to the pins on the chip

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7400 family Digital Logic Chips

A set of digital logic chips that provide functionality like AND, NOT, OR,……

You will use several 7400 family chips to build logic circuits

The gate layout and chip characteristics are specified by a **Datasheet**

- Datasheets available on the web
- http://www.skot9000.com/ttl/
- http://rabbit.eng.miami.edu/info/datasheets/74LS04.pdf – for 74LS04

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What is a Datasheet Introduction

Provide important information about the device
Most useful sections: Pin Layout diagrams and Function table

Other information: electrical and temperature-related characteristics about your chip, physical layout of your chip (dimensions are even provided!)

Reading datasheets is a necessary skill to understand chip layout

See appendix for more info on reading datasheets

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Datasheet Example

1. Go to the internet and search for "74HC04"
2. Find a link that leads to a datasheet
   - Websites like mouser and digikey are often good for this
3. Determine where the power and ground connections on this chip are.
4. How many NOT gates are packaged onto this chip ?

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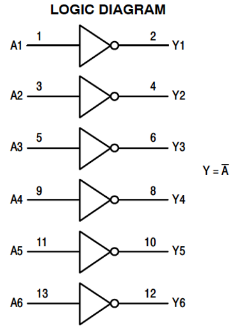
74HC04 – Invertor

- This is the information we need to use the chip in a circuit

FUNCTION TABLE

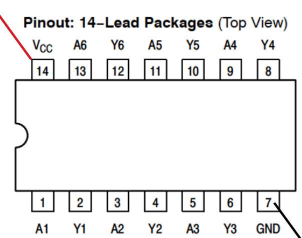
Inputs	Outputs
A	Y
L	H
H	L

LOGIC DIAGRAM



Y1= NOT (A1)
Y2 = NOT (A2)
…

Connect this Pin to Power (+ve)



Connect this Pin to Ground (- ve)

If you connect both Vcc and GND to same lines on Breadboard you will short the circuit
and ….the chip will fry !

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Lab exercise 1: Circuit Using Inverters

You will build a circuit with three inputs (x1,x2,x3) and three outputs (y1,y2,y3)
- y1 = NOT (x1)
- y2 = NOT (x2)
- y3 = NOT (x3)

Manually connect the input to power (for a value of 1) or ground (for a value of 0) using wires

Connect each of the outputs to an LED (and the necessary resistor) to visualize what your circuit is doing

Test for all values of xi

Measure voltages at yi using multimeter

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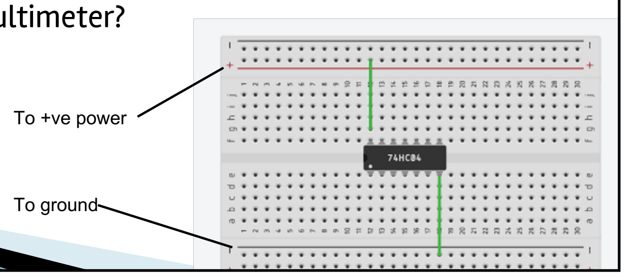
Lab exercise 1: Circuit Using Inverters

You will build a circuit with three inputs (x1,x2,x3) and three outputs (y1,y2,y3)
- y1 = NOT (x1) y2 = NOT (x2) y3 = NOT (x3)

1. Get necessary components (resistor, LED, IC, wires)
2. BEFORE you connect the IC to breadboard, determine how it will be oriented and connected to power (do not short it !)
3. Wire up the 3 inputs, connect LEDs (& resistor) to IC outputs
4. connect power source to breadboard
5. Test values using multimeter?



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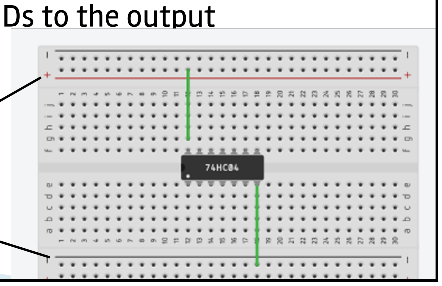
Lab exercise 2: Circuit Using two chips

You will build a circuit with two inputs (x1,x2) and one output F = (NOT X1 OR NOT X2)

Get necessary components (resistor, LED, ICs, wires)

- What is the IC for OR gates....check datasheet for 74LS32N

1. Connect power source to breadboard
2. BEFORE you connect the ICs to breadboard, determine how it will be oriented and how they will be connected to each other
3. Wire up the 2 input and connect LEDs to the output
4. Test values using multimeter



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Lab Homework 1

Use multiple chips to build a circuit that computes: F= (A OR NOT B) AND (B OR NOT C)

First identify the chips to be used.

Next, draw a circuit and determine how the pins will be connected between the chips

Implement on the breadboard

Show demo to the UTAs or LAs – deadline is next lab.

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Other components in your lab kit

DIP switches
Pushbutton switches
Various 7400 series chips
Screwdriver, wire stripper,….

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Appendix:
How to Read a Datasheet

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Introduction

The datasheet:

- Is packed with information
- Tells you about electrical and temperature-related characteristics about your chip
- Gives you a physical layout of your chip (dimensions are even provided!)

Ability to pick out relevant information about the device you are using is a valuable skill

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Breaking down the datasheet

1. Title
2. Part/Device Description
3. Packaged Diagrams
4. Function Table
5. Logic Diagram
6. Recommended Operation Conditions

Important: Pay attention to which pins are Voltage (Vcc) and Ground (Gnd)..you could fry your chip if you switch the polarity !

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Example: Inverters (NOT gates)

SN5404, SN54LS04, SN54S04,
SN7404, SN74LS04, SN74S04
HEX INVERTERS
SDLS029C – DECEMBER 1983 – REVISED JANUARY 2004

description/ordering information

These devices contain six independent inverters.

Datasheet Title

2. Datasheet Part/Device Description

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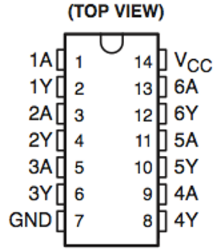
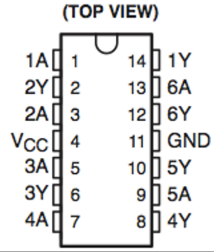
3. Datasheet Packaged Diagrams

SN5404 . . . J PACKAGE
SN54LS04, SN54S04 . . . J OR W PACKAGE
SN7404, SN74S04 . . . D, N, OR NS PACKAGE
SN74LS04 . . . D, DB, N, OR NS PACKAGE
(TOP VIEW)

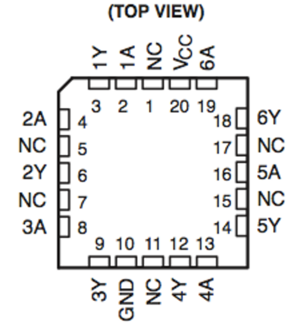


Always look for the correct part #

SN5404 . . . W PACKAGE
(TOP VIEW)



SN54LS04, SN54S04 . . . FK PACKAGE
(TOP VIEW)



NC – No internal connection

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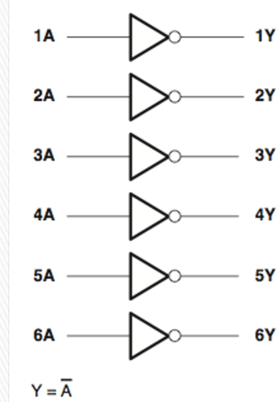
FUNCTION TABLE (each inverter)

INPUT A	OUTPUT Y
H	L
L	H



Function Table

Logic Diagram

H = high
L = low

Q: What does this say about how an inverter works?

A: Takes your signal and flips its state (0 → 1,1 → 0)

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6. Recommended Operating Conditions

Again, find the correct part #

recommended operating conditions (see Note 3)

		SN5404			SN7404			UNIT
		MIN	NOM	MAX	MIN	NOM	MAX	
V_{CC}	Supply voltage	4.5	5	5.5	4.75	5	5.25	V
V_{IH}	High-level input voltage	2			2			V
V_{IL}	Low-level input voltage			0.8			0.8	V
I_{OH}	High-level output current			−0.4			−0.4	mA
I_{OL}	Low-level output current			16			16	mA
T_A	Operating free-air temperature	−55		125	0		70	°C

NOTE 3: All unused inputs of the device must be held at V_{CC} or GND to ensure proper device operation. Refer to the TI application report, *Implications of Slow or Floating CMOS Inputs*, literature number SCBA004.

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6. Recommended Operating Conditions (cont'd)

electrical characteristics over recommended operating free-air temperature range (unless otherwise noted)

PARAMETER	TEST CONDITIONS‡			SN5404			SN7404			UNIT
				MIN	TYP§	MAX	MIN	TYP§	MAX	
V_{IK}	V_{CC} = MIN,	$I_I = -12$ mA				−1.5			−1.5	V
V_{OH}	V_{CC} = MIN,	V_{IL} = 0.8 V,	$I_{OH} = -0.4$ mA	2.4	3.4		2.4	3.4		V
V_{OL}	V_{CC} = MIN,	V_{IH} = 2 V,	I_{OL} = 16 mA		0.2	0.4		0.2	0.4	V

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Good Reads for understanding V_{OH}, V_{IL}, V_{OL}, V_{IH}

http://www.allaboutcircuits.com/textbook/digital/chpt-3/logic-signal-voltage-levels/

https://learn.sparkfun.com/tutorials/logic-levels

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DIP Switch

set of tiny switches in one package (housing)
housing looks like a chip

Can set switch to ON or OFF

- They are toggle switches, i.e., they have two possible positions – on (1) or off (0).
- Connect one side (inputs) to power bus (Vcc)
- Connect other side (output) to your circuit
- If ON then output = 1 (Vcc)
- OFF then output = 0 (ground)
- You can also swap things so that ON=0 and OFF=1
  - Will cover this next class when discussing pull-up and pull-down resistors

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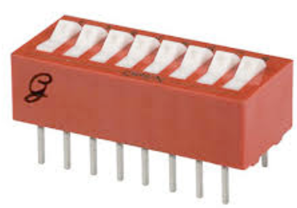
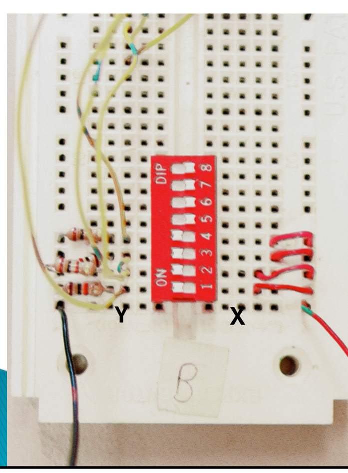
DIP Switch





If switch is set to ON then closed circuit – X connects to Y
If switch is set to OFF then no connection

Ex: If X goes to Vcc (1),
then ON means Y=1
OFF means Y=0

Note: Best to use small screwdriver (or pen tip) to set switches

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