

ECT 213
Spring 2008
Lab #3
Combinational Logic Circuits

Name: _____

Purpose: To introduce the student to breadboards and TTL logic circuit wiring.

Introduction: If you have never used a Protoboard (aka Breadboard), it is recommended that you watch <http://www.youtube.com/watch?v=oiqNaSPTI7w> and <http://www.youtube.com/watch?v=Mq9XMNsoAd8&feature=related> before proceeding. These videos are much more in depth then the review that follows.

Protoboards and Digital Circuits: The most common way to connect circuits for testing purposes is to use a protoboard (aka breadboard). Protoboards typically look like the following figure:

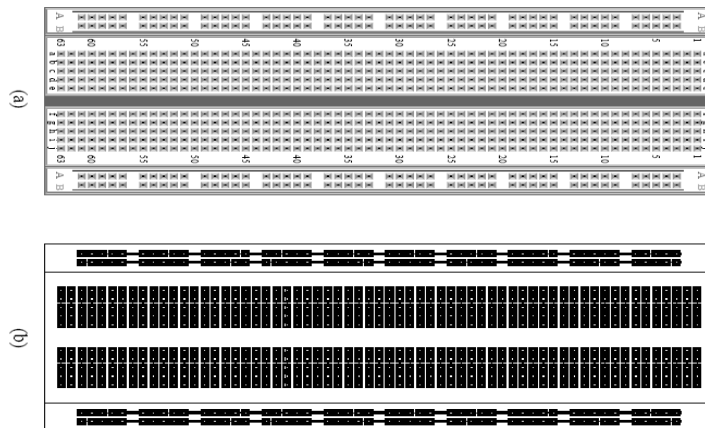


Figure 1 - Protoboard.
a) top b) bottom

A few features should be noted. First of all the two rows on the top and bottom of the board are typically used for power and ground. These connections go the length of the board on most proboards, but not always. You should always verify this each time you use a new board.

The space in the center of the board is designed for Integrated Circuits (aka IC's). Since the columns on each side of this space are NOT connected, this allows the IC to be connected properly by straddling this space (see below).

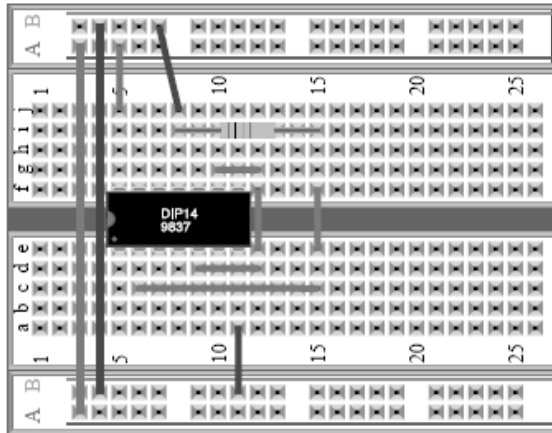


Figure 2 - IC on breadboard

Since we will be using IC's in Dual Inline Packages (aka DIP Package) in this class. You will need to be able to identify PIN 1 on IC's. This can be done using the following indicators:

- the U shaped indentation is the top of the IC. The pin to the left is PIN 1
- a small dot is sometimes placed above PIN 1 (but not always)

The pins are then counted in a U pattern (from pin 1 down, across the IC then back up the other side).

Here are two examples:

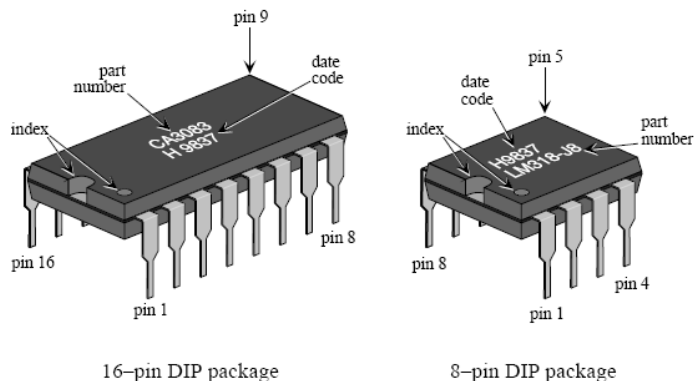


Figure 3 - IC Pin Identification

Typically, when digital logic circuit schematics are drawn (using Multisim or other schematic capture program) the pin numbers are shown on the schematic. It should be noted that many IC's in the digital logic family contain more than ONE GATE PER IC. Usually each gate in the same IC are labeled with the same ID number and a letter (A is the first gate, B the

second gate and so on). The U_x (where x is a number) shows the IC number. An example is shown below:

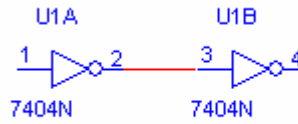


Figure 4 - Schematic Example

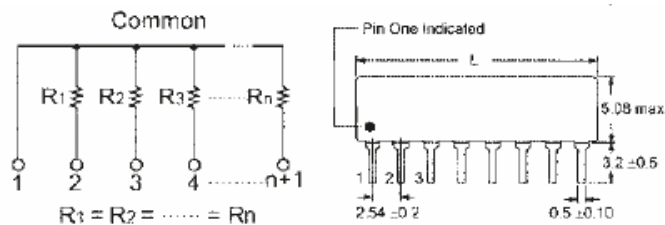
So in this circuit, there is one IC (U1), and it uses two gates on that IC. Gate one's (A) input is on pin 1 and the output is on pin 2. The second gate (B) has its input on pin 3 and its output on pin 4. The IC is a 7404N (74xxx series is TTL and is the most common digital logic series of IC's).

It should be noted the POWER and GROUND are **NOT SHOWN** on most digital logic schematics. To find where Power and Ground should be connected, look on a "DATA SHEET". A Data sheet is the technical specifications of the electronic component. Electronics manufacturers provide these for the IC's they produce. Typically you can find a data sheet for a component by typing in the PART NUMBER of the component into an internet search. So if you type in "7404" into a search engine (like Google), you will probably find a link to a data sheet in .pdf format.

Power is typically labeled as VCC and Ground is labeled as GND. VCC for all IC starting with '74' is +5 VOLTS (Applying higher voltages or a negative voltage can result in damage to the component!!!)

Inputs to digital logic circuits have to be supplied with +5v to indicate a high and Ground to indicate a low. For this circuit, read the section on "THE PULL UP RESISTOR" at <http://www.seattlerobotics.org/encoder/mar97/basics.html>.

We will be using Single Inline Package (SIP) Resistors for this experiment. A SIP resistor has multiple resistors that have one side of each resistor tied to a common pin. This pin can be connected to ground for PULL DOWN resistors and to Power in the case of PULL UP resistors. Pin one of the SIP (the common pin) can be identified by a dot, as shown below:

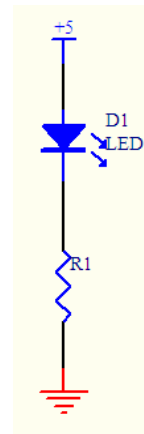


Typically, SIPS do NOT use the standard resistor code. Instead they have a 3 digit number (e.g. 183). The first two digits are like the first two colors of the resistor color code, each representing a digit. The last number is the power of 10. So for the example, 183, this mean $18 \cdot 10^3$ or $18,000\Omega$ or $18K\Omega$.

You will also use Light Emitting Diodes (LED) in this experiment. These semiconductor devices give off light when connected correctly. Since they are semiconductors, they are **polarity sensitive** (i.e. if you hook them up backwards they will not work and can be damaged). Make sure you connect them as follows:

LED devices typically need a resistor in series to limit the amount of current though the device. Most LED are rated with a voltage and current rating. For example a typical LED will be rated with $1.7V @ 20mA$.

To calculate the resistor needed, use OHM's LAW using the following circuit:

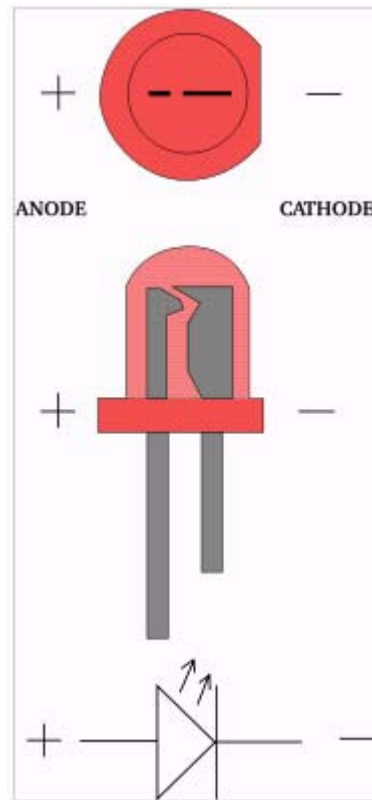


Using the rating of the LED, we know that $1.7V$ drop across the LED and $20mA$ flow though the LED.

Since this is a series circuit, we know $20mA$ must also flow though the resistor.

We also know that if 1.7 volts drop across the LED, $5-1.7$ or $3.3V$ must be across the resistor.

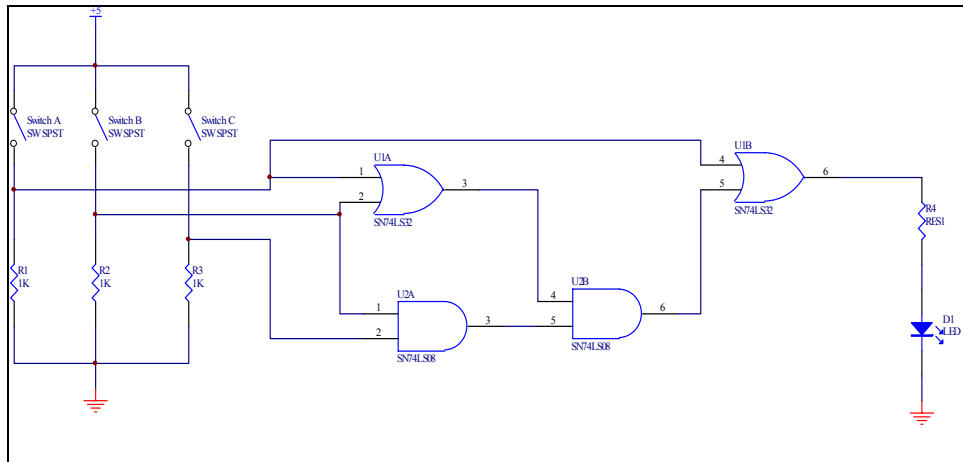
So we have the voltage drop across the resistor and the current so using Ohm's Law: $R=E/I$, so $R=3.3V/20mA$ or 165Ω .



Lab

Procedure:

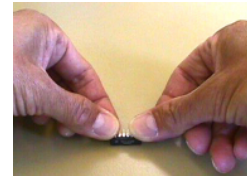
Using last week's circuit, build the circuit using ONE 74LS08, ONE 7432 IC, ONE 1K SIP resistor, ONE DIP Switch, ONE 330Ω SIP resistor and one LED:



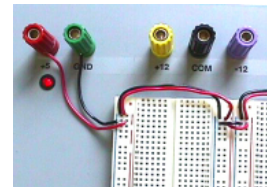
NOTE: Connect the above circuit with R4 and the LED swapped (ie pin 6 of the 7402 to the positive of the LED, negative of the LED to ground). Also note that R4 = 330Ω resistor.

HINTS¹:

If the IC is new and never used, straighten all leads on each side by placing the IC on its side on the bench and press firmly on it in order to bend the pins to a 90-degree angle.

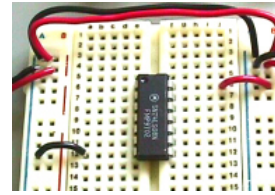


Connect +5V and GND to vertical rails on the solderless breadboards. Distribute these to all other vertical rails to create +5V and GND buses. Use wire of the same colour for all +5V connections, e.g. red, orange or yellow. Use another color for GND, e.g. black, brown, green, blue.

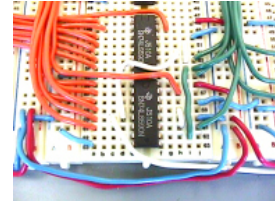


¹ <http://www.physics.mcmaster.ca/phys4d06/Lab/chapter5.htm>

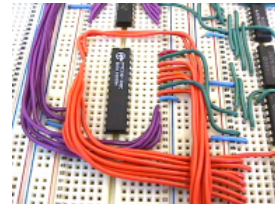
Connect the Vcc and GND pins of the IC to the power bus using short jumpers. Be consistent with use of color.



Make use of colored wires to differentiate different connections.



Try to keep all wiring short and tidy and avoid laying wires over the IC, just in case you have to remove the IC. Make use of colors to differentiate the signal functions.



Once connected *complete the truth table below using the constructed circuit:*

Inputs			Output
A	B	C	Z

Demonstrate your circuit to the instructor and have him initial below:

What is the Boolean expression for the circuit?

Now simplify the equation (showing your work).

Draw the simplified circuit. Number the pins for the gates with the next gates on the IC's already in use (on the AND IC, gates on pins 1,2,3 and 4,5,6 are in use and on the OR IC gates on pins 1,2,3 and 4,5,6 are also in use). Refer to the data sheet for the pin numbers of gates not in use.

Without destroying the 1st circuit, wire the simplified circuit (above) using the same switch inputs already in use. Connect an LED in series with a second 330Ω resistor.

Once connected, complete the circuit using the simplified circuit:

Inputs			Output
A	B	C	Z

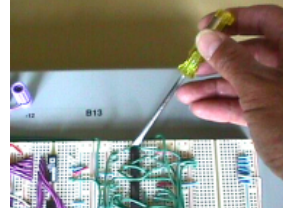
Verify that the two circuits have the same output by comparing the truth tables.

Demonstrate your circuit to the instructor and have him initial below:

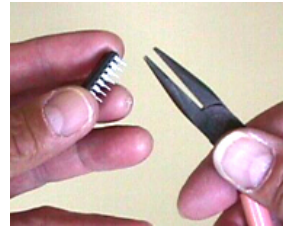
When taking apart your circuit please note the following:

More Hints²:

Do not use your fingers to remove the ICs from the breadboard. Use the flat screwdriver to gently pry away the IC by alternating at **both ends** of the IC. **Do not crowbar the IC from one end.**



If you bend a pin, carefully bend the pins using needle-nose pliers to straighten them.



² <http://www.physics.mcmaster.ca/phys4d06/Lab/chapter5.htm>