Input/Output hardware introduction

Prerequisites

To enable you to complete this lab assignment you do not need to be able to design logic circuits. You preferably should have:

- Hardware
  - a protoboard with the following components:
    - DIL 8-switch package
    - 1 K-Ohm SIP resistor
    - 330 Ohm SIP resistor
    - SN7405 open-collector Hex Inverter
    - 6 LEDs
    - 22-gauge wire of different colors
  - a pair of fine-nosed pliers,
  - a pair of wire cutters, and
  - a logic probe.

- Knowledge
  - a basic knowledge of Ohm's Law and how it applies to simple passive circuits and
  - the unit multipliers between μ (micro) and M (Mega) and how to convert between them.

To fully appreciate the assessment feedback it would be useful to have at least a simple understanding of Bloom's taxonomy of educational objectives (later in the course)

Objectives

The purpose of this lab is to set up the switch circuitry and LED network to allow you to input logic levels easily to your circuits during the coming semester; and to be able to detect a number of output levels simultaneously. You will also be introduced to a number of electronic and logic components including a DIL (Dual In Line) switch block, SIP (single in-line package) resistors, an open-collector gate, and LEDs.

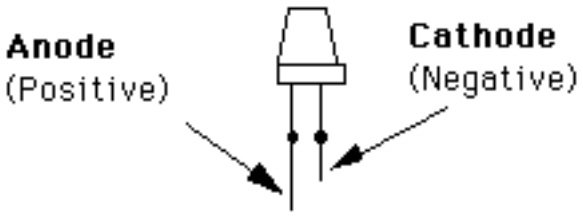
Background

A logic probe will help you to look at a single point in your circuit but it is useful to have an array to look at multiple points. It is suggested that when you have set up the input circuit and output circuit that you leave them on your protoboard for future use, hence they ought to be 'logically' at the ends or corners of your board.

The LEDs take a variety of shapes from round-topped red cylinders to rectangles. You might also have a bank of 8 LEDs in a DIL package. You should try to arrange them so that they are in a straight line and easy to read. The hole spacing on your protoboard is 1/10 inch both vertically and horizontally. However you should note that although the anode-cathode spacing is 1/10 inch, the width

of the LEDs is not a multiple of 1/10 inch. You may have to be creative to produce a tidy display.

LED



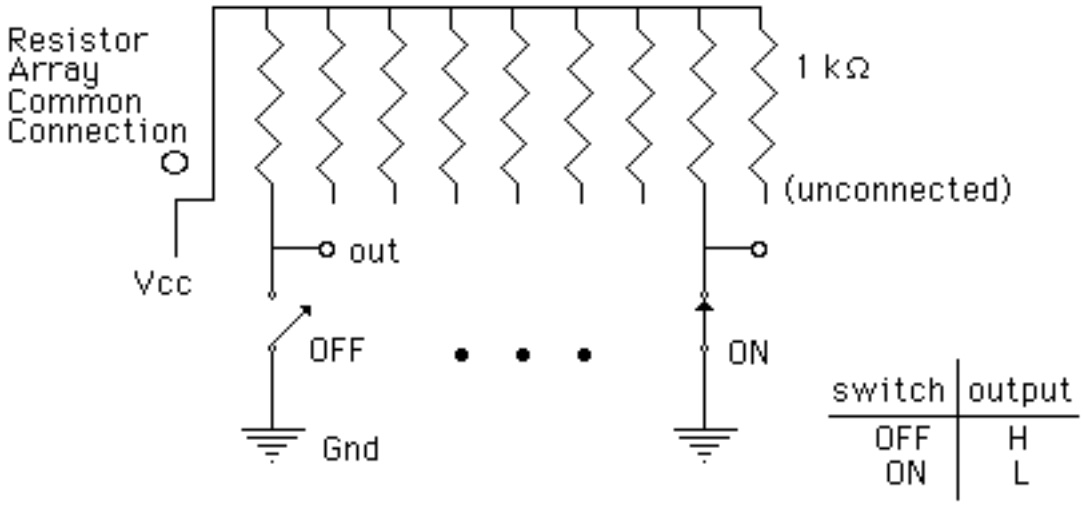
You may have LEDs arranged as the diagram above or separate round-topped devices. In either case, please note that the long end of each pair of leads is the one that should go to the positive voltage.

Theory

Input Circuitry

The basic theory is based on the electrical characteristics of switches and pull-up resistors. The circuit shown below is the schematic for the input circuit. The components in this circuit are to provide you with input (voltage) logic levels. Your kit contains SUIP (single in-line package) resistors of values 330 Ohm and 1 K-Ohm. You also have a DIP (Dual In-line Package) set of eight switches. They should be connected as diagramed below:

Input Configuration Schematic
(using 1 k-ohms x 9 SIP)

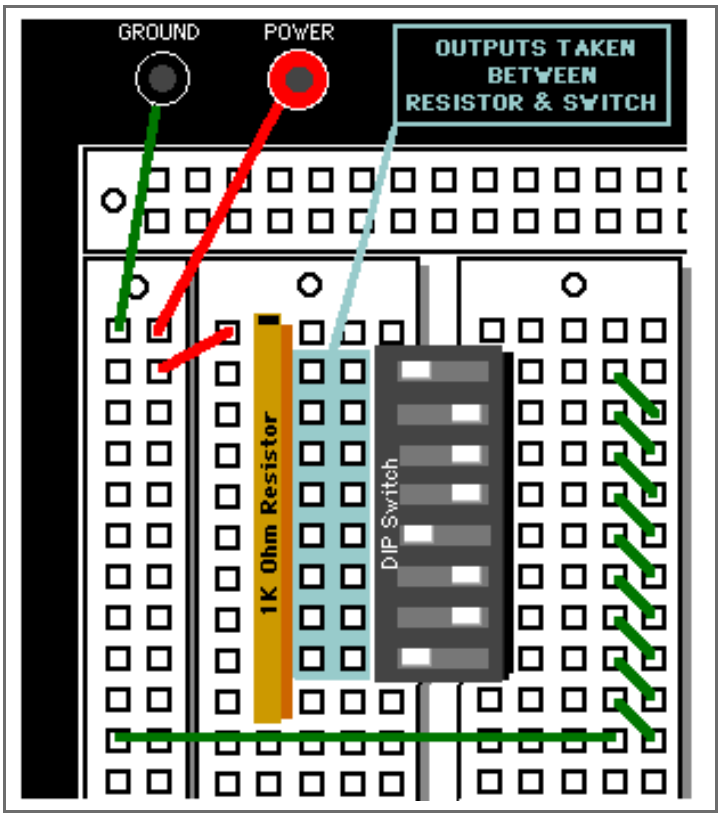


The common point of the SIP resistor is connected to Vcc and each of the other pins is connected to a switch, which itself is connected to ground as shown. The output from this switch circuit is taken from the points between the resistors and switches.

Protoboard Circuit

When a switch is closed, it creates a short-circuit from the out point to ground and thus a logic "0" is present. When the switch is open the out point is not connected to ground but is connected to Vcc via a resistor. Since no current flows through this resistor there is no voltage drop across it and the out point is therefore at Vcc voltage.
Examine the diagram below that shows how you can set up the input circuit on your protoboard.

Input Circuit for Protoboard



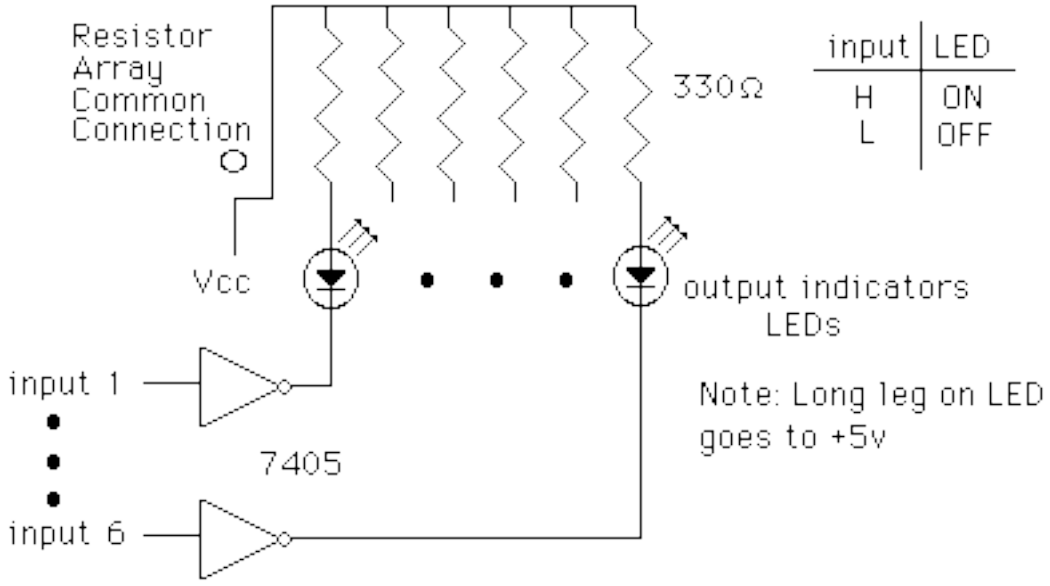
If you have a logic probe you can test this part of your assignment by probing the column of the protoboard between the SIP resistor and the switch as indicated in the diagram below. We also suggests that you mark your protoboard with a 1 and a 0. This will help you remember which way the switch should be for each logic state.

Output Circuitry

The circuit shown below is for the output circuit that will allow you to monitor up to six outputs at the same time. The SIP resistor has only six 330 Ohm resistors so, with the common leg, has 7 legs. You must make sure that you use the SN7405 chips and not the SN7404 chips for the inversion. [Note that for normal logic inversion a SN7404 is used but in this circuit we need to drive an external load, hence the open collector gates]. The connection should be as below:

Output Configuration Schematic

(using 330-ohms SIP Resistors & 7405 Hex Inverters)



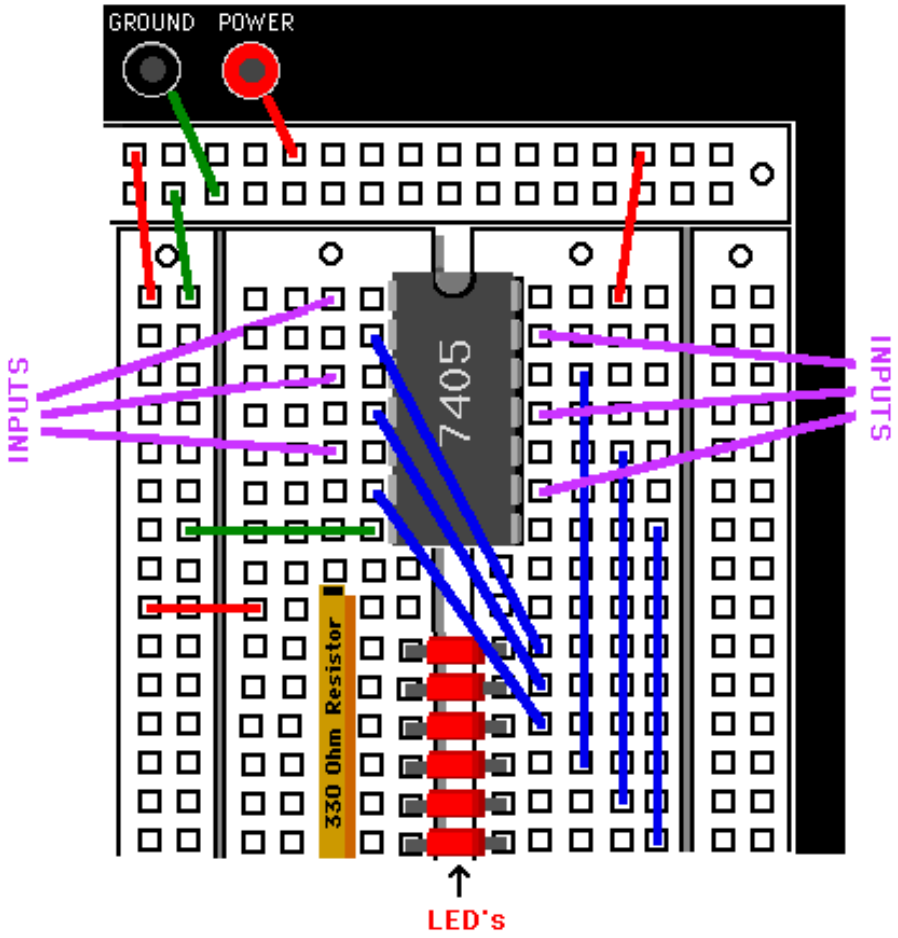
The inputs to this circuit numbered 1 through 6 go into the input pins of the inverter gates in a SN7405 chip. These inverters change logic **0**'s to logic **1**'s and vice versa. Like the input switch circuit the common leg of the SIP resistor is connected to Vcc. Each of the other pins is connected to the anode of a LED. The cathode of each LED is connected to an inverter.

Protoboard Circuit

If a logic **1** is put on input 1, then the inverter produces a logic **0** at its output, the cathode of the LED. This logic **0** is at ground potential so there is then a Vcc-minus-0 voltage across the LED and resistor which lights the LED. If a logic **0** is put on input 1, then the inverter produces a logic **1** at its output, the cathode of the LED. This logic **1** is at Vcc potential so there is then no voltage across the

LED and resistor and no light is emitted. The diagram showing the output LED circuit on a protoboard is below.

Output Circuit for Protoboard

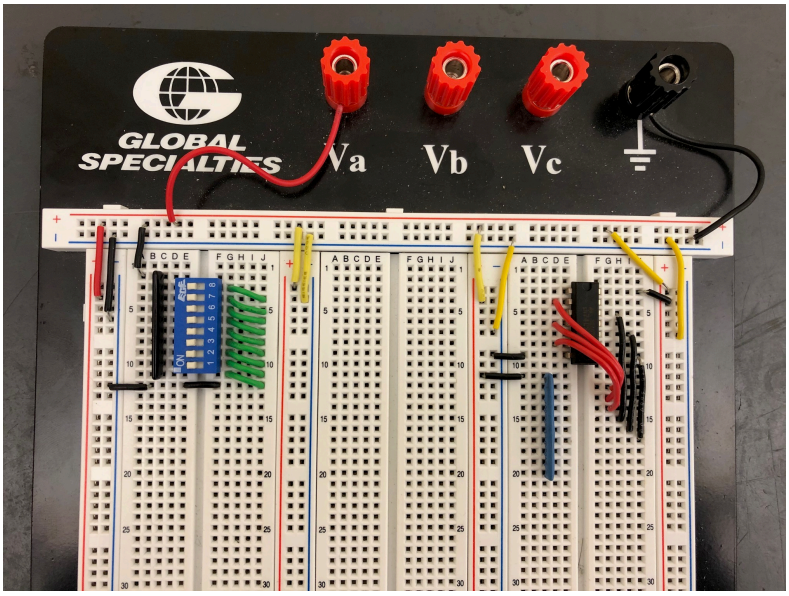


Procedure

Follow the diagrams shown in the theory section and build the circuits accordingly.

You should try to be as tidy as possible so that the circuits are robust and reliable. You might also think about color-coding your wires so that the Vcc lines are red, for example, the Ground lines are green or black, and the signal wires are some other colors. This will help in identifying the logic lines and in debugging your circuits when they fail - as they almost certainly will!

An example of a very tidy design is shown bellow (LEDs are not added).



Check the pin connections of the 7405 chip on your component list sheet. It is very important to connect the power correctly with the Vcc level to pin 14 and the Ground to pin 7.

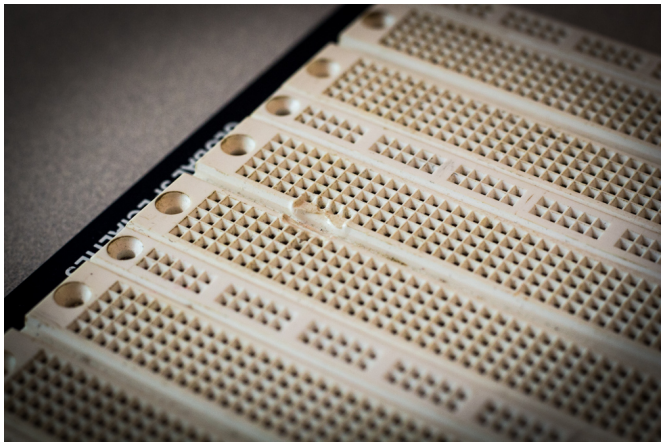
Testing

This is simple since you have no design involved. You should take a wire from each of the "out" points and connect it to one of the inverter inputs. To test your circuits change each of the switches to check the effect on the LEDs. If a switch is to the right i.e. giving a **0** out then the corresponding LED should be off, if the switch is to the left then the corresponding LED should be on.

Note: If you did not have SN7405 inverters in the LED output circuits there would be light for a **0** and no light for **1**. This would be negative logic!! This is OK but can be confusing when you are trying to analyze a fault in your design. If you have made your circuits tidy and robust and placed them in convenient positions on your protoboard, you can leave them there, with confidence, for the remainder of the semester.

Advice

If you mis-wire your circuit on your protoboard (for instance by having your +5 (Power) and zero (Ground) the other way round) you will find that your chip will get extremely hot. To convince yourself you can put your finger of it – which will hurt - or spray some spit – which will sizzle. The damage will also be to the board itself as shown below.



Secondly, if you find that you have broken wire in one of the protoboard slots TAs may be able to pull it out with a periodontal tool. Ask.

Deliverables

The only deliverables for this piece of work are the working input and output circuits on your protoboard that you need to demo to TAs and answers to the following questions. No formal report is required.

Reference

http://en.wikipedia.org/wiki/Light-emitting_diode#Other_white_LEDs

Questions

Why are we using the 7405 inverter instead of the 7404? You may need to do some additional online research to answer this question.

How much current will your LED be taking (roughly)?