Objectives

The purpose of this lab is to set up the switch circuitry and LED network to allow you to input logic signals easily to your circuits and to observe a number of output signals simultaneously. The idea is to get the input and output circuits completed so you can concentrate on your logic design and circuit building in later labs. This assignment will give you hands-on experience with a number of electronic components including circuit boards, a Dual In Line (DIL) switch block, Single In-line Package (SIP) resistors, an open-collector chip, LEDs. There is no design involved but skill of building according to lab instructions. We assume that you have a basic knowledge of Ohm’s Law and how it applies to simple passive circuits. Since this is likely to be the first time that you have attempted to construct a circuit, you need to learn how to cut and strip wires without cutting yourself. You will also learn how to insert and extract wires and other components like chips.

Hardware

You will need the following hardware components.

- 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.

You should also have a piece of styrofoam on which you can store chips and prevent breaking the pins.
Specifications

Although a logic probe helps you to look at a single point in your circuit, it is more convenient to have an array to look at multiple signals. After you have set up the input circuit and output circuit, leave them on your protoboard so you can use them in later labs. Hence, ‘logically’, they ought to be at the ends or corners of your board.

The light-emitting diodes (LEDs) (see Figure 1) 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.

![Figure 1: Light-emitting diode (LED).](image)

You may have LEDs as shown in Figure 1 or as round-topped devices. In either case, the long end of each pair of leads is the one that should go to the positive voltage.

Input Circuitry

The basic theory is based on the electrical characteristics of switches and pull-up resistors. The circuit in Figure 2 is the schematic for the input circuit. The components in this circuit provide you with input logic signals. Your kit contains Single In-line Package (SIP) resistors of 330 Ohm and 1K Ohm. You also have a Dual In-line Package (DIP) set of eight switches. They should be connected as diagramed in Figure 2.

The common point of the SIP resistor is connected to Vcc and each of the other pins is connected to a switch. The other end of the switch is connected to ground as shown in Figure 3. The output from this switch circuit is the points between the resistors and switches.

When a switch is closed, it creates a short-circuit from the output point to ground and thus a logic “0” is present. When the switch is open the output 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. The out point is therefore at the Vcc voltage.

In Figure 4, the protoboard on the left shows how you may set up the input circuit on your protoboard. The protoboard on the right depicts location of positive voltage and the ground on the protoboard after the circuit is set up. Consider the protoboard on the right in Figure 4.
and take a minute to think what is the voltage flow after the top most switch is flipped from the OFF position to ON.

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 as shown. This will help you remember where the switch should be for 0 or 1.

**Output Circuitry**

The circuit shown in Figure 5 is the output circuit, which allows you to monitor up to six signals at the same time. The SIP resistor has six 330 Ohm resistors and seven legs, one of which is the common leg. You must make sure that you use the SN7405 chips, not SN7404, for the inversion. (Note that for normal logic inversion a SN7404 can be used. In this circuit, however, we need to drive an external load so the open collector gates are used here). The connection should be as in Figure 5.

The inputs to this circuit numbered one through six 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 (see Figure 6).

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 depicted in Figure 7.

**Procedure**

Follow the diagrams shown earlier 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. For example, the Vcc lines are red, the ground lines are green or black, and the signal wires are some other colors. This will help identifying the logic lines and debugging your circuits when they fail - as they almost certainly will!

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.
When switch (a) is at 0, b becomes 1. There is no voltage across the LED and it remains off. When switch (a) is at 1, b becomes 0. There is a voltage across the LED and it lights.

Figure 6: Output circuit in LogicWorks.

Figure 7: Output circuit on protoboard.

Testing
Take a wire from each of the “out” points and connect them 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, the corresponding LED should be off. If the switch is to the left, 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.

Having made your circuits tidy and robust, and placed in convenient positions on your protoboard, you can leave them on your board and use them with confidence for the remainder of the semester.

Deliverables
You will work individually on this assignment. The deliverables are working circuits on your protoboard. No lab report is required.