Lab# 13: Introduction to the Digital Logic

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Print Name:

In this lab you will become familiar with Physical and Logical Truth tables. As well as asserted high, asserted low, active low, and active high logic.

In this exercise, you will implement six simple circuits, each using one of six basic logic chips. Each of the logic gates requires two input signals, and the same two inputs can drive all circuits at the same time. These two inputs arise from two slide switches. The output of each logic gate will be connected to an LED. Note that all of the chips have more than one logic gate – for this exercise, you can simply ignore all but one gate. The six logic chips are:

- 74HC00 quad two-input NAND gate
- 74HC02 quad two-input NOR gate
- 74HC04 hex inverter
- 74HC08 quad two-input AND gate
- 74HC32 quad two-input OR gate
- 74HC86 quad two-input XOR gate.

In this lab we will utilize pull-up resistors and pull-down resistors in conjunction with a SPST switch to create the input signals for the logic gate (SPST = single pole single throw). The two examples are shown below.



Typically the smaller of the two resistors is simply made $\sim 0\Omega$ (a wire). The schematic on the left is the pull up. The output is pulled up to LHV thorough the R₁ pull-up resistor. You can also think of this as a "weak" connection to LHV. When the switch is closed, the output is pulled down to LLV. (Think voltage divider with R₁>>R₂.) The complementary circuit is the pull down (the schematic at the right).

You will measure physical truth tables and logical truth tables. The physical truth table is simply the physical behavior of the circuit. The logical truth table depends on the logical meaning attached to the voltages. A logic signal is said to be *asserted high* or *active high* when LHV is true (1) and LLV is false (0). The opposite case is logic signal that are *asserted low* or *active low* when LLV is true (1) and LHV is false (0). As we will see, the two definitions result in different logical operations from the SAME physical truth table!



In this lab we will make use of SIP resistor networks with a common buss to simplify construction of our circuits. Common buss means that one of the pins of the package connects to one leg of all the other resistors. What is really nice is that they fit into you breadboard and to is a very easy way to make pull ups and pull downs. You will be provided with 22Ω , 100Ω and 10K SIP resistors. The 10K resistors are for the pull ups and pull downs (the weak connections). The 22Ω SIP resistors are used as the small resistor to work against the pull-up and pull-down resistors. Typically these connections would just be wires, but then you'd need lots of wires. If we use the 22Ω SIP resistor, we can save time. The 100Ω Sip resistors will be used as the current limiting resistors for your LEDs.



Eight independent SPDT switches in a 16-pin DIP package. The SPDT switches make connection between the pins on the opposite rows (see diagram).

The switches you will use are also in a DIP package. Insert these into the breadboard straddling the grove as you did with the op amp. The switch is closed when the slide actuator is positioned against the side labeled "on".



The LED anodes are on the same side as pin one.

The LEDs are also in a DIP package. This package has ten independent LEDs. Insert these into the breadboard straddling the grove as you did with the op amp. The polarity is shown by the notch, which identifies pin 1.



Logic Diagrams for the six chips required in this lab

This information is included for reference. Note all the logic chips have VDD (+5V) and GND (common) at diagonally opposite ends of the chip, for 14-pin dips these are pins 14 and 7, respectively. NOTE: Four of the chips have the inputs and outputs mapped to the same pins. The exception is the NOR. The inverter is also different in this regard.



Part 1. Build the circuit above. Construct the physical truth table for each of the gates. To do this, record the output voltages for all four combinations of input voltages. Use you DMM to measure the voltages with respect to the circuit common. In your table enter LHV for \sim +5 V and LLV for \sim 0 V. Also complete the table for the switch and the LED

chip →	SW1	SW2	' 00	'02	'04	'08	' 32	' 86	device	physical LLV/LHV	device state
	LLV	LLV							switch		off (open)
	LLV	LHV							output		on (closed)
	LHV	LLV							LED		off (dark)
	LHV	LHV							input		on (illum)

Now construct the logical truth table. For the inputs, take switch "on" (closed) = 1, and the switch "off" (open) = 0. For the outputs take the LED "off" = 0 and the LED "on" =1. In the last line of the table, state the logic operation performed by each gate (use the logical truth table).

SW1	SW2	'00	'02	'04	'08	' 32	'86
0	0						
0	1						
1	0						
1	1						
logic \rightarrow							



Part 2. Build the circuit above. Construct the physical truth table for each of the gates. To do this, record the output voltages for all four combinations of input voltages. Use you DMM to measure the voltages with respect to the circuit common. In your table enter LHV for \sim +5 V and LLV for \sim 0 V. Also complete the table for the switch and the LED

chip →	SW1	SW2	' 00	'02	'04	'08	' 32	'8 6	device	physical LLV/LHV	device state
	LLV	LLV							switch		off (open)
	LLV	LHV							output		on (closed)
	LHV	LLV							LED		off (dark)
	LHV	LHV							input		on (illum)

Now construct the logical truth table. For the inputs, take switch "on" (closed) = 1, and the switch "off" (open) = 0. For the outputs take the LED "off" = 0 and the LED "on" =1. In the last line of the table, state the logic operation performed by each gate (use the logical truth table).

SW1	SW2	'00	'02	'04	'08	' 32	'86
0	0						
0	1						
1	0						
1	1						
logic \rightarrow							

Questions (60 homework points) Give short answers to the following questions.

- 1. (5 points) What is a "signal" in a digital circuit?
- 2. (6 points) How is pin 1 of an IC located (give two methods)
- 3. (12 points) An LED requires 20mA of current to show the presence of a LHV output in a 3.3 V system. The LED requires a 1.3V drop in order to emit light. What size of current-limiting resistor should be used? Sketch the circuit.
- 4. (5 points) How much power is dissipated in the resistor in the problem above?
- 5. (12 points) In you circuit, a 100 Ω resistor was used with the LED and 5 V as the power supply. Assuming that $V_f = 1.3$ V for the diode. Find the current through the diode and the power dissipated in the resistor.
- 6. (10 points) In part 1, is the assertion level high or low? In part 2?
- 7. (10 points) The chips you used have standard logic labels, for example the '00 is a NAND. (See the figure in this lab.) Do these logic operations correspond to a high or low assertion level?