The University of Texas at Dallas
Department of Computer Science
CS 4141: Digital Systems Lab

Experiment #1 – Familiarization with Lab Equipment and Simple AND, OR, NOT, NAND, NOR and XOR Functions

CS 4141 Laboratory 1, EXPERIMENT

Introduction

This course is intended as a companion laboratory to CS4341-Digital Logic and Computer Design. As such, we will be becoming familiar with simple digital circuits in the lab sessions, since these relatively simple circuits make up all of the functional units in even the most sophisticated digital computer systems and microprocessor chips.

Objective

The purposes of Experiment #1 are to:
(1) familiarize students with the laboratory equipment on which all of the digital hardware exercises will be performed
(2) to understand the operation of the fundamental logic gates – the AND, OR, NOT, NAND, NOR, XOR.

Turn-In Check List

The laboratory has two items to grade.

1. Demonstrate the working circuits to the Lab Instructor (40 points)
2. ***Put supplies away correctly sorting and returning all chips. (10 points)***
3. Produce the Post-Lab Report. (30 points)

Equipment List

The following components are required for this experiment:

- IDL-800a Digital Lab Station (“breadboard” unit with test equipment built-in power supply)
- AND gate IC Chip (Such as SN74LS08)
- NOT gate IC Chip (Such as SN74LS04)
- OR gate IC Chip (Such as SN74LS32)
- NAND gate IC Chip (Such as SN74LS00)
- NOR gate IC Chip (Such as SN 74LS02)
- XOR gate IC Chip (Such as SN 74LS86)
- Breadboard wires (jumpers)

Experimental Procedure

Part 1. The IDL-800a

Step 1) Become familiar with the IDL-800a chassis (refer to the manual at any time if additional clarification is needed). Note that the rear panel (forward-facing near-vertical panel at the back of unit) contains the master power on-off switch. In addition, the left side of the panel contains a function generator which can generate an electrical signal in three forms: sinusoidal, triangular, and square wave. Both the frequency and amplitude can be varied. On the right side of the panel, there is a digital voltmeter that can measure various voltages applied to circuits. Note that the voltmeter can be connected either to banana plugs or the small wire connectors that are used to connect circuit pins together.

Step 2) Study the flat portion of the IDL-800a chassis. On the left side are two +5VDC (non-variable) power outputs, plus a variable DC supply with outputs of 0-15 and 0-(-15) V. On the right are wire connector-to-banana plug adapters and other inputs (which will not be used in this lab). At the bottom are some function switches that can apply +/− 5V, and two “pulse” switches which will apply a 1 (5V) or 0 (0V) as long as they are held down. There are also 8 “data” switches that can be switched to apply 1 or 0 (5V or 0V) to any input. At the rear of the flat board are data indicators, including two seven segment displays which will display numbers, and 8 light-emitting diode (LED) indicators which can be connected to circuit pins to indicate whether a one (5V) or a 0 (0V) is present. A 1 will light up the LED; a 0 turns it off.

3) The center of the flat chassis area is the prototype board. At the top and bottom are “power busses.” When these are connected by the small solid copper wires to one of the supplies (red to +, blue to ground or 0), all the other holes in the respective lines connect to that voltage element.

4) Note that the prototype board contains two main areas of pins. When a chip is plugged into any set of pins in such a way that it bridges the wide space in the middle of each pin group, all pin holes in each vertical column which contains a chip pin are also connected to that pin. Thus, other components, inputs, or voltages can be connected to each pin of the circuit being evaluated.

5) Take some time to study the chassis and ask questions to the instructor or TA if necessary.

Part 2. NOT Gates, AND Gates, as well as OR Gates

Part 2.1 The NOT Gate

Step 1. Find the hex inverter (74LS04) or similar inverter chip and carefully plug it into the breadboard in either the upper or lower section. Make sure that the long dimension of the chip package points left-right, with the notch on the left, and that the chip "legs" bridge the wide space in the middle of the hole array. The exact location of the chip from left to right on the board is arbitrary.

Step 2. Make sure the master power is off. Using the small solid copper wires from the kit supplied, connect +5V to pin 14 and 0V (ground) to pin 7. Remember that the "notch" is located on the end of the chip where pin 1 is. Looking down from the top, pin 1 is on the left, and pin 14 is on the right; pin numbering is counterclockwise from 1 to 14 (refer to diagram on last page).

Step 3. There are six inverters (NOT functions) on the chip. Any will do equally well, but this example uses the first, which has input on pin 1 and output on pin 2. Connect one of the data switch outputs at the bottom of the panel (bottom right) to the input (pin 1) of the inverter. Connect the output of the inverter (pin 2) to one of the LED diode inputs at the top of the horizontal portion of the IDL-800. Make sure that the data switch is in the 0 position.

Step 4. Turn on the power. Verify that the LED is on; since the input is 0, the output should be 1 (0V), so the diode should be illuminated.

Step 5. Turn the data switch to 1. Verify that the LED is extinguished. The input is now 1, so the output is NOT-1, or 0. Toggle the switch several times to verify that the inverter or NOT gate output is always opposite of the input.

Step 6. Turn off the power and disconnect the circuit connections.

Part 2.2 The AND Gate

Step 1. Find the 74LS08 chip and plug it into the board as you did the 74LS04. Connect pins 7 and 14 to ground and +5V as before. Note that there are 4 equal AND circuits on the chip, but these instructions use the first one numerically (refer to the pin-out diagram as needed).

Step 2. Connect two data switches to the AND gate inputs, pins 1 and 2. Make sure both inputs are 0. Connect the AND gate output, pin 3, to an LED input.

Step 3. Turn on the power. Verify that the LED is off. Turn one data switch on (to 1). The LED should stay off. Turn that data switch back to 0, and turn the other to 1. The LED should still be off. Now turn both switches on (to 1). The LED should light. This verifies that the AND function is as defined – the output is 1 if both inputs are 1. Try this switching several times to get the "feel" of the circuit.

Step 4. Turn off the power and disconnect the circuit connections.

Part 2.3 OR Gate

Step 1. Find the 74LS32 chip and plug it into the board as you did the other circuits. Connect pins 7 and 14 to ground and +5V, respectively, as before. Note that there are 4 equal OR circuits on the chip, but these instructions use the first one numerically (refer to the pin-out diagram as needed).

Step 2. Connect two data switches to the OR gate inputs, pins 1 and 2. Make sure both inputs are 0. Connect the OR gate output, pin 3, to an LED input.

Step 3. Turn on the power. Verify that the LED is off. Turn one data switch on (to 1). The LED should light up. Turn that data switch back to 0 and turn the other to 1. The LED should light up once again. Now turn both switches on (to 1). The LED should light under this condition also. This verifies that the OR function is as defined – the output is 1 if either or both inputs are 1. Try this switching several times as above to get the "feel" of the circuit.

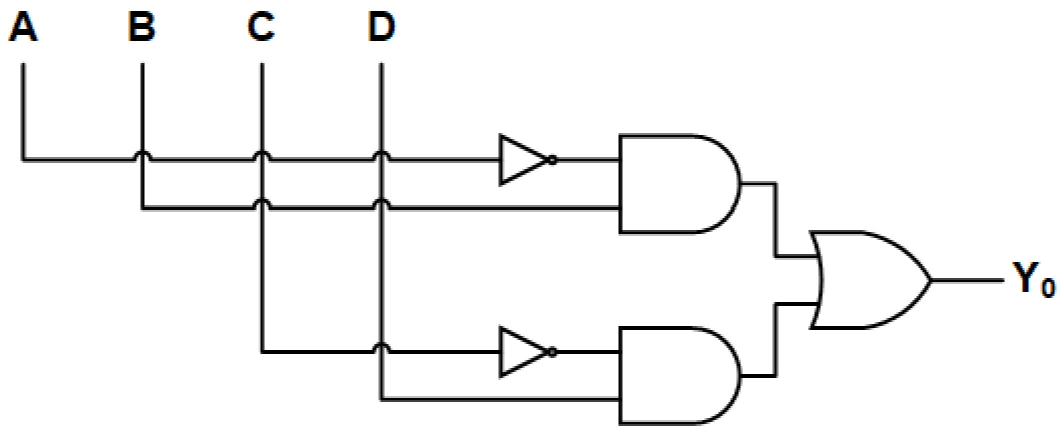
Step 4. Turn off the power and disconnect the circuit connections.

Part 3. Solving for Boolean expressions:

Note: Multiplication represents an AND gate. Addition represents an OR gate, and an apostrophe represents a negation. Exclusive Disjunction (⊕) represents an XOR gate.

For example:
Y_0=A'•B+C'•D would represent Y = (NOT A AND B) OR (NOT C AND D)

And equation Y_0 would look like this logic diagram.



Convert each of the following equations to circuits and draw the equivalent logic gate diagram and *record the results as a truth table*. These logic diagrams and the accompanying truth table will be come part of your post lab report.

3.1 Y_1 = (A • B) + (C • D)'
3.2 Y_2 = (A' • B') + (C • D)
3.3 Y_3 = (A • B)' + (C' • D')
3.4 Y_4 = (A ⊕ B) + (C ⊕ D)

Equipment Disassembly: The experimental procedure is complete. Please disassemble the circuit wiring, replace in the wires and replace all IC chips in their proper boxes. Make sure that your work area is clean.

For the Post-Lab Report (30 points)

- First, include your name, section, and date of the experiment.
- Second, include the title "Experiment 1 Post-Lab"
- If you were working with a partner on a lab station,
    - Then include your partners' name
- For each equation in section 3, include
    - the equation (4x2.5 points each for 10 points)
    - the logic diagram (4x2.5 points each for 10 points)
- the truth table (4x2.5 points each for 10 points)
- Citations: If you are using software to draw your diagrams, identify the software. 10 point penalty.