

GEORGIA INSTITUTE OF TECHNOLOGY
School of Electrical and Computer Engineering
ECE 2020
Lab #1: Digital Logic Module

GOAL

To introduce the physical implementation of design logic circuits including the use of logic gates, Boolean algebra, mixed logic, integrated circuits, and breadboards.

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EQUIPMENT NEEDED

- NAND gate (SN74LS00N)
- NOR gate (SN74LS02N)
- NOT gate (SN74LS04NE4)
- Jumper wires
- Breadboard
- NI myDAQ

BACKGROUND

Breadboard: Breadboards (also known as protoboards) make many connections under the board in order to reduce the number of wires that you have to connect. Typically, groups of 5 holes are connected. The side rails are lines of 5 that are all connected. See Figure 1 below.

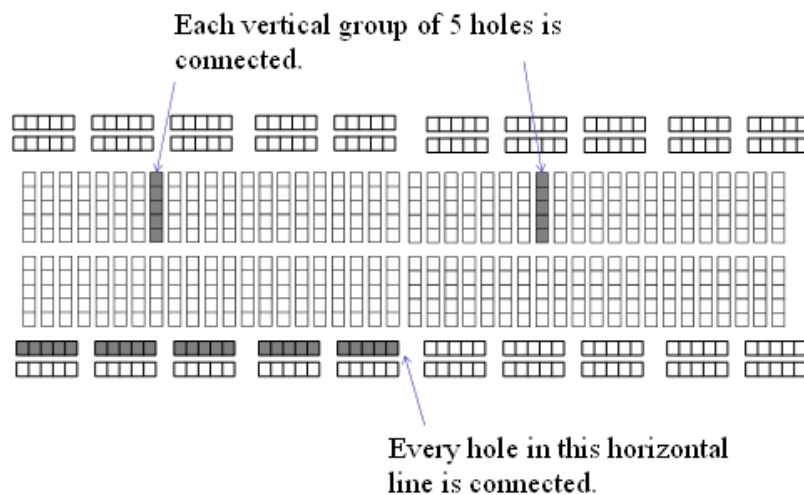


Figure 1. Breadboard Layout

Integrated Chip: An integrated chip can have several gates (circuits) on it. For example, the MC74HC08AN chip has 4 AND gates wired as shown in Figure 2 below. It has 14 wire pins coming out the sides, including a ground (GND) and a high voltage (V_{cc}). The notch is used to determine the orientation, so that PIN 1 is just to the left of the notch.

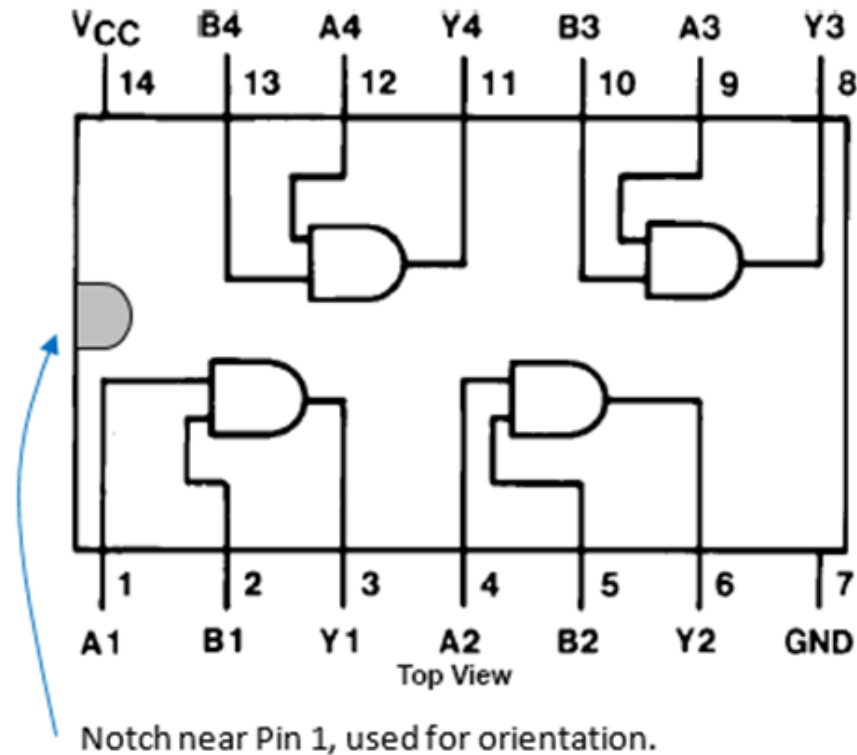


Figure 2. MC74HC08AN Pin Layout

Pin Diagram: A pin diagram helps to wire the circuit. A pin diagram simply puts appropriate pin numbers next to gate inputs and outputs. See Figure 3 below for an example of a pin diagram.

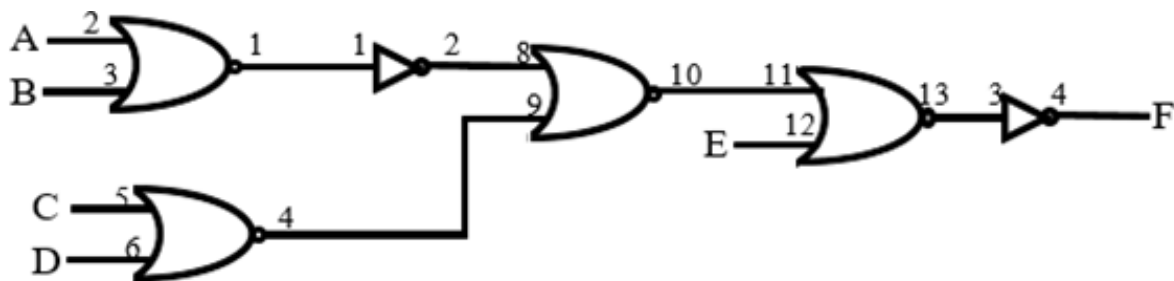


Figure 3. Pin Diagram: This is interpreted as wiring the A input line to PIN 2 of the NOR gate IC, and PIN 1 of the NOR gate IC to PIN 1 of the NOT gate IC, etc.

National Instruments myDAQ: Digital Acquisition Boards (DAQs) are used to measure physical electrical signals and convert them into a form that can be viewed and stored digitally. The National Instruments myDAQ also has analog and digital output signals. The digital input/output (DIO) lines are labeled 0-7 in the side view of the myDAQ. Also shown below in Figure 4 are the digital ground (DGND) and the high

voltage, +5v. The myDAQ comes with several software instrument panels including a digital reader and digital writer panels.



Figure 4. National Instruments myDAQ

PRE-LAB ASSIGNMENT

- 1) Every Student needs to download the NI ELVISmx software, install it on your laptop, and bring your laptop to class. Make sure that the NI ELVIS Instrument Launcher software runs. *This process takes about an hour to do.* Failure to do this may result in not being able to perform the laboratory exercise. The software can be found on the National Instruments website at: <http://joule.ni.com/nidu/cds/view/p/id/2157/lang/en>.

For students using a MAC, you will need to install the software on a Windows partition and run it from there. The experiment will be done in pairs, so if you cannot get this software to run on your machine, then make sure that you arrange to have a partner who can run it.

- 2) View the introduction videos at:
<https://www.youtube.com/watch?v=psrfAgDvYfs>
<https://www.youtube.com/watch?v=kdORHmtCoQ>
- 3) Read the Background section of this laboratory exercise.

Do the pre-lab circuit design problems: Use the expressions given by your instructor or the expressions in the appendix, if your instructor has not given you expressions. For each case, use mixed logic to design the circuit to be implement the logic expression with only NAND gates or NOR gates and NOT gates. Show the truth table for the circuit.

PRE-LAB PROBLEMS (complete work on a separate piece of paper)

- 1) Use mixed logic to design an implementation for $F = \overline{A}B + C$ using only NOR or NOT gates. Draw your final design using only the NOR and NOT gate symbols. Give a truth table for this expression.
- 2) Use mixed logic to design an implementation for $F = \overline{A+B+C}$ using only NAND and NOT gates. Draw your final design using only the NAND and NOT gate symbols. Give the truth table for this expression.

LAB PROCEDURES

1) myDAQ Setup

- Connect the myDAQ to your USB port.
- Start the NI ELVIS Instrument Launcher software. Click on the DigIn and DigOut icons to open the Digital Writer and Digital Reader. The panels will look like those in Figure 5 below. The digital IO lines can be configured as read lines (outputs from your circuit to be read by the myDAQ) or write (outputs from the myDAQ to your circuit). Select lines 0-3 as write lines and lines 4-7 as read lines.

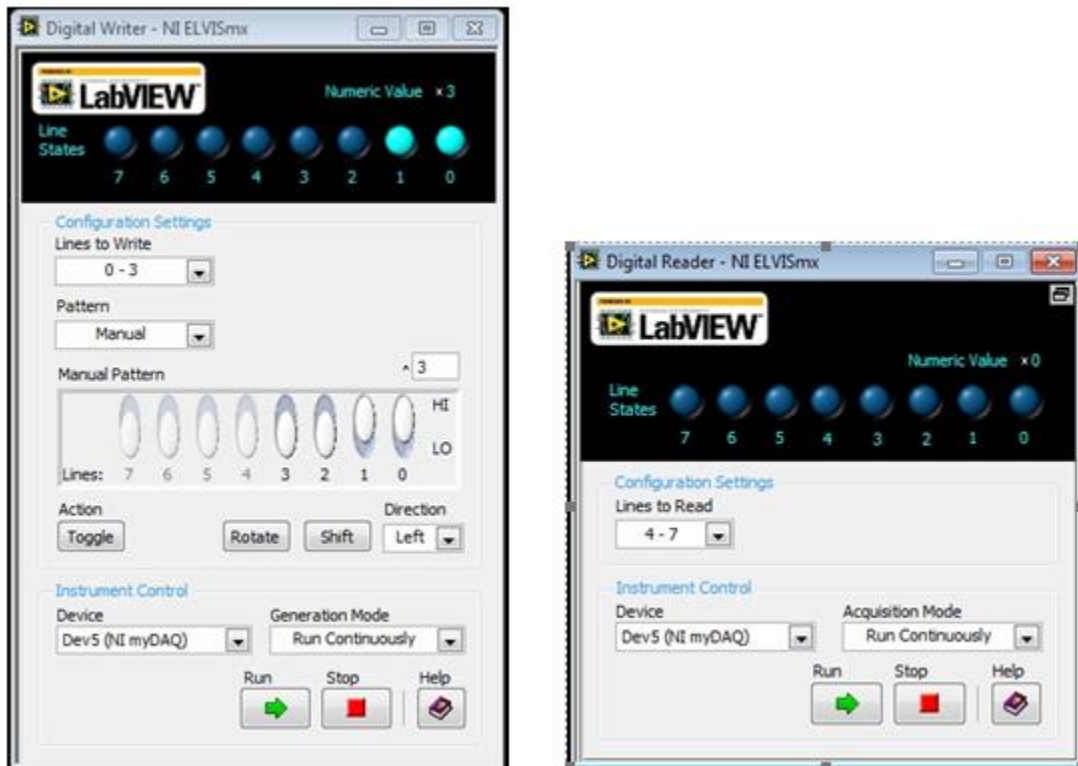


Figure 5. Digital Writer (left) and Digital Reader (right)

- The Digital Writer panel image shows that Lines 0 and 1 are set to high voltage (+5v). This is a logical value of "1". Lines 2 and 3 are set to low voltage (ground), which is a logical "0". The mouse is used to toggle the input values between 0 and 1. The indicator lights on both panels light with a logical 1 to that line. Click on the "Run" button when starting your measurements or the "Stop" button to end the experiment.

Not working? Try this:

- If the available software screens do not give the icons for the digital writer or reader, then you may have started NI LabVIEW instead of NI Elvis Instrument Launcher. Terminate that program and try again.
- If the software does not seem to be working as expected, did you plug the myDAQ into the computer USB port *before* starting the software? If not, then terminate the program and try to run it again with the hardware connected.

2) Connecting a NOT Gate

This experiment is done with two-person groups. Pick one partner to connect the IC and the wires and the other partner to work the software. You may coach each other, but please do not take over for your partner.

- Insert the NOT gate into your protoboard where the gate straddles the center gap.
PLEASE REVIEW THE VIDEO FIRST. The pins are very fragile. Connect the digital ground to PIN 7 and high voltage +5v to PIN 14. Review the data sheet information in Figure 6 below on an Inverter IC (SN74LS04N). There are six NOT gates with inputs labeled 1A, 2A, ...,6A and corresponding outputs labeled 1Y, 2Y,...,6Y.
- Connect a digital I/O line (any line 0, 1, 2, or 3) from the myDAQ to NOT gate input 1A (PIN 1). Then connect an I/O line from 4-7 to the NOT gate output 1Y.
- Verify that you connected the NOT gate correctly by testing it (using the myDAQ software) to make sure that if the input to the NOT gate is a 1, then the output is 0. Toggle the input to make sure that a 0 input yields a 1 output.

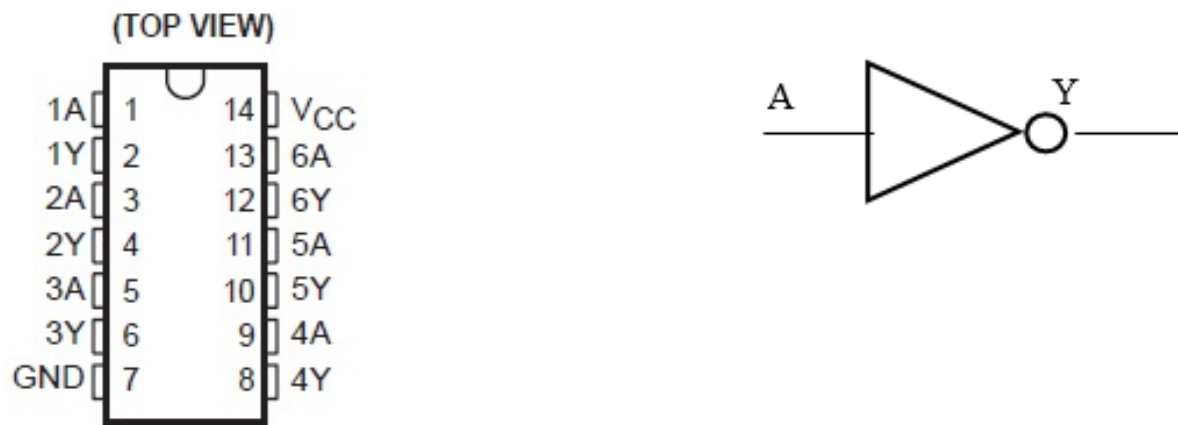


Figure 6. Inverter IC (SN74LS04N) Pinout (left) and NOT Gate Diagram (right)

Chips not working or not working as expected? Troubleshooting:

- Check the orientation of the chip, by seeing where the notch is in the chip and put the ground and +5V lines to the appropriate pins.
- Double check your digital input and output lines match the ones you are manipulating in software. If you hooked up to lines 2 and 3, then those are the ones you should be turning on and off.
- You have double-checked all your connections and it still is not working properly. Use the digital output line to measure the power to the chip and the ground to the chip. (Connect line 4 to each of these and see if they have the appropriate levels, 0 or 1).
- Check for loose wires into the protoboard or out of the myDAQ. Use the screw driver to refasten loose wires in the myDAQ terminal.

3) Connecting a NOR Gate

Switch the roles of the partners so that you each have a chance to run the software and to configure the circuit.

- Insert the NOR gate into your protoboard where the gates straddle the center gap. *The pins are very fragile.* Connect the ground to PIN 7 and +5v to PIN 14.

- b. Review the data sheet information below on a two-input NOR gate (SN74LS02N). There are four NOR gates labeled 1-4, each having inputs A and B and output Y. So, inputs 1A and 1B go into the first NOR gate, which has the corresponding output 1Y.

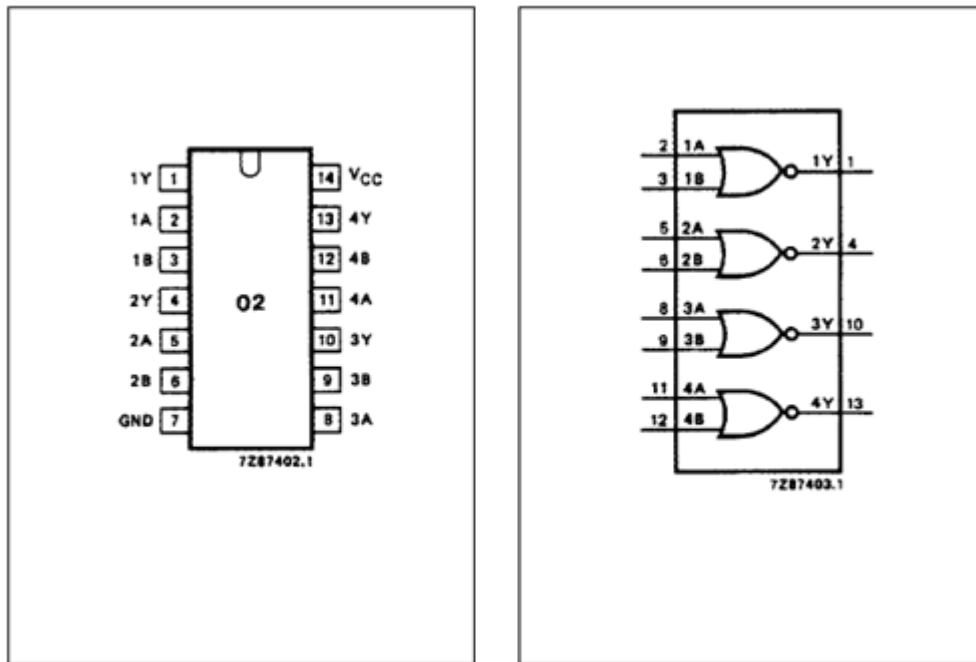


Figure 7. NOR Gate Pinout (left) and Logic Symbol (right)

- c. Connect digital I/O lines from the myDAQ to the inputs to two NOR gates.
 d. Verify that you connected the NOR gate correctly by testing it to make sure that it implements the truth table for a NOR gate.

Check-offs (put answers on sheets provided in Appendix B)

1) Implement Problem 1 from the Pre-lab

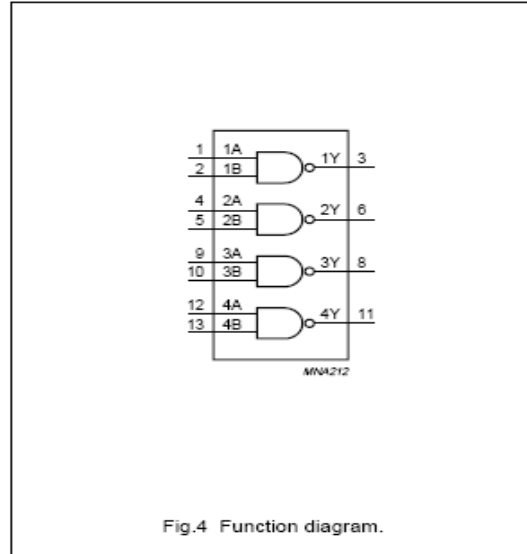
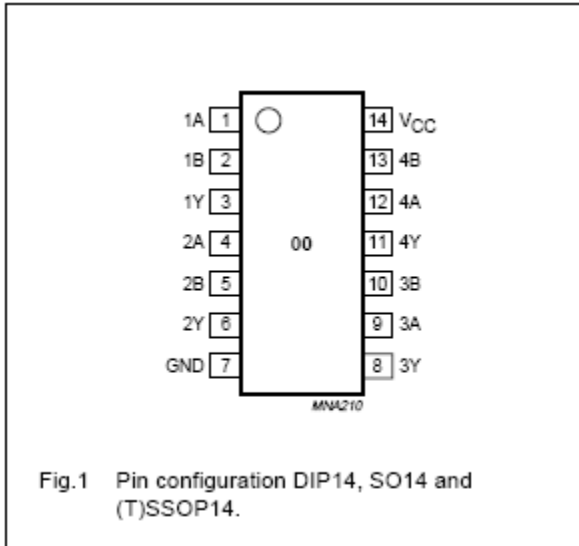
- a. Draw the circuit showing the final design. Make sure to include the pin numbers (see the background section on pin diagrams).
 b. Give the truth table for the Boolean Algebra expression.

2) Implement Problem 2 from the Pre-lab

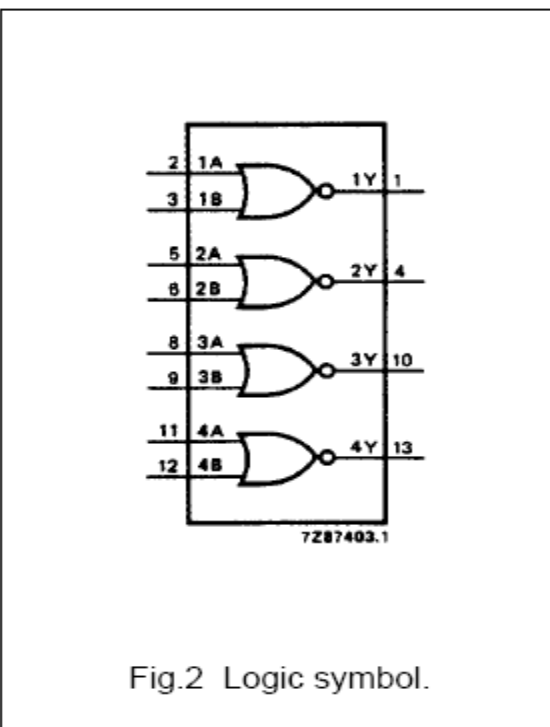
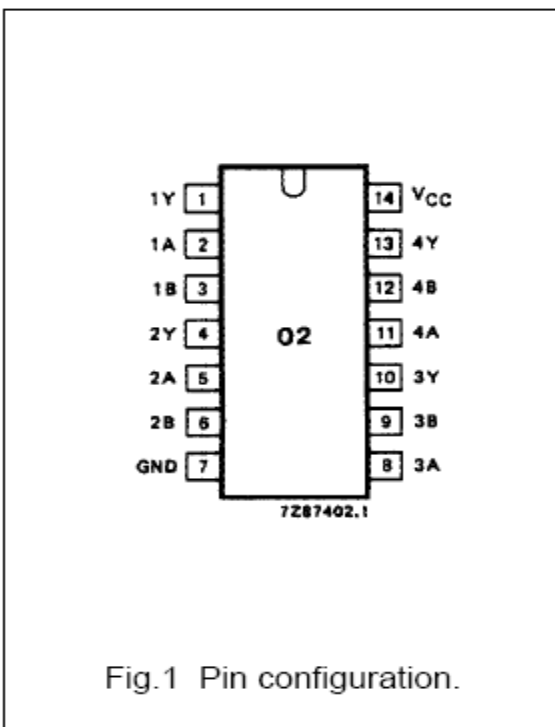
- a. Draw the circuit showing the final design. Make sure to include the pin numbers (see the background section on pin diagrams).
 b. Give the truth table for the Boolean Algebra expression.

Appendix A: Datasheet information for different gates

NAND Gate IC (74HC00) or (SN74LS00N):



NOR Gate IC (74HC02) or (SN74LS02N):



NOT Gate IC (74HC04) or (SN74LS04N):

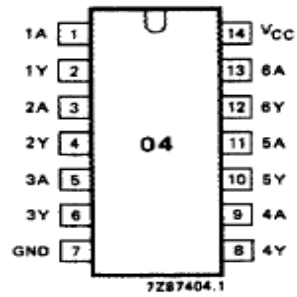


Fig.1 Pin configuration.

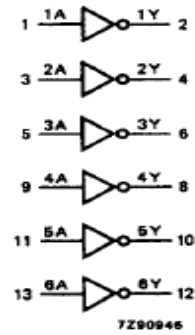


Fig.2 Logic symbol.

Appendix B: Answer Sheet

(Check-off question #1 should be done on this page)

TA Initials: _____

(Check-off question #2 should be done on this page)

TA Initials: _____