Digital Logic Module: Lab Procedures

Goal: to introduce the physical implementation of digital logic circuits including the use of logic gates, Boolean algebra, mixed logic, integrated circuits, and breadboards.

Contents:

- Prelab Assignment Page 1
- Background Page 1
- Lab Procedures Page 4
- Appendix A: Default Prelab Problems Page 7
- Appendix B: Data sheet information for gates Page 8

Equipment Needed:
- Pre-wired setup with NAND (74LS00N), NOR (74LS02N) and NOT (74LS04N) gates.
- Jumper wires kit
- 9V battery and connector

Pre-Lab Assignment
1) Read the Background section of this laboratory exercise.
2) Do the pre-lab circuit design problems: Use the expressions in the appendix. For each case, use mixed logic to design the circuit to be implement the logic expression with only NAND and NOT or NOR and NOT gates. Show the truth table for the circuit.

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 groups of 5 that are all connected. See the example figure.

Integrated Chip: An integrated chip can have several gates (circuits) on it. For example, the MC74HC08AN chip has 4 AND gates wired as shown below. It has 14 wire pins coming out the sides, including a ground (GND) and a high voltage (Vcc). The notch is used to determine the orientation, so that PIN 1 is just to the left of the notch.
Pin Diagram: A pin diagram helps to wire the circuit. A pin diagram simply puts appropriate pin numbers next to gate inputs and outputs. For example.

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.
Figure A: Pre-built board
Lab Procedures

A) Pre-built board Setup

- Orient the board in front of you as shown in Fig. A.
- Connect the 9V battery as shown in Fig. A. The red wire (+9V) goes to the left most (+) rail on the breadboard. The black wire (- or GND) goes to the (-) rail on the board. Make sure the power switch next to it is in the down position (turned OFF when you are wiring the rest of your circuit) with respect to the orientation of the board as shown in Fig. A.
- The voltage regulator converts the 9V input to 5V needed by the ICs in your circuit.

B) Testing a NOT Gate

The gates are already connected to the power rail for you.

a. Review the data sheet information below on an Inverter IC (SN74LS04N). There are six NOT gates with inputs labeled 1A, 2A, …,6A and corresponding outputs labeled 1Y, 2Y,…,6Y.

b. Connect a Input line (any line 1-4 from right side of the DIP switch in Fig. A) to NOT gate input 1A (PIN 1). Then connect the output line (resistor next to the led in Fig. A) to the NOT gate output 1Y.

c. Turn on the supply. Top switch to the UP position.

d. Verify that you connected the NOT gate correctly by testing it. Toggle the input from the DIP switch to up position to feed in logic HIGH (making output low i.e. led is off). The toggle it to down position to feed in logic LOW (making output high i.e. led is on).

e. Turn of the power (top switch down).

C) Testing a NOR Gate

Again the gate is already powered for you.

a. 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.
b. Connect two inputs from the DIP switch to the two inputs of the same NOR gate.
c. Connect output as before from the output of the NOR to the led and turn on the circuit.
d. Test the gate by toggling the inputs from the DIP switch as before.
e. Turn off the supply.

D) Implement Part A) from the Prelab
   a. Draw the circuit below showing the final design. Including the pins (see the background section on pin diagrams).
b. Give the truth table for the Boolean algebra expression.


c. Have the TA sign off on your implementation.

TA Initials ____________

E) Implement Part B) from the Prelab
   a. Draw the pin diagram showing the final design.

   b. Give the truth table for the Boolean Algebra expression.

   c. Have the TA sign off on your implementation.

   TA Initials ____________

F) Turn off the supply and disconnect the battery from the board and the connector from the battery. Remove all the wires you connected on the board. (DO NOT remove anything that was already there on the board). Neatly put the used wires back into the wire kit and turn in all the equipment to your TA.
Appendix A: Default Prelab Assignment

Use Mixed Logic to design a circuit to implement the expression given by the instructor using only the gates allowed. The default expression (if none is given by the instructor) is

**Part A):** Use mixed logic to design an implementation for \( F = \overline{AB} + C \) using only NOR and NOT gates. Complete your work here. Draw your final design using only the NOR and NOT gate symbols. Give the truth table for this expression.

**Part B):** Use mixed logic to design an implementation for \( F = \overline{A + B + CD} \) using only NAND and NOT gates. Complete your work here. Draw your final design using only the NAND and NOT gate symbols. Give the truth table for this expression.
Appendix B: Datasheet information for different gates

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

Fig. 1 Pin configuration DIP14, SO14 and (T)SSOP14.

Fig. 4 Function diagram.

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

Fig. 1 Pin configuration.

Fig. 2 Logic symbol.
NOT Gate IC (74HC04) or (SN74LS04N):

Fig. 1 Pin configuration.

Fig. 2 Logic symbol.