CS223 Laboratory Assignment 1

Digital Circuits: Logic to Gates

Lab dates and times:

Section 1:	Lab: Mon 08:40-12:30 in EAZ-04
Section 2:	Lab: Wed 08:40-12:30 in EAZ-04
Section 3:	Lab: Tues 08:40-12:30 in EAZ-04
Section 4:	Lab: Thur 08:40-12:30 in EAZ-04

Location: EA Z04 (in the EA building, straight ahead past the elevators)
Groups: Each student will do the lab individually. Group size = 1

Preliminary Work (35 points)

(You should do this part before coming to lab) read the document posted in Unilica for CS223 labs: "Circuit Schematic versus Logic Diagram".

Recommendations

In CS223 labs, you build circuits by ICs and later by FPGA. It is better to obey some simple rules to avoid damaging electronic parts or confusing yourself with debugging your circuit.

- Avoid touching IC or FPGA pins directly by your hand. Static electricity of your body can damage them permanently.
- The white board which you setup your circuit on it, is called "breadboard". Search in internet and find out how its pins are connected internally.
- Postpone connecting power pins (Vcc and ground) to last step. Check circuit connections and if everything seems ok then connect power pins.
- For easier debugging of curcuits, always follow a wire color convention. For example, always use black or whilte wire for ground and red wire for Vcc.
- If LED's light is weak, or if the IC's package is very hot (you can touch plastic parts) you have a problem in power pin connections (short circuit, connecting Vcc wire to ground pin,...).

Part 1: Practice with Logic Gates (30 points)

Physical gates are built out of transistors, and require physical signals that use correct voltage levels for inputs and produce physical signals with correct voltage levels for outputs. To work correctly, the transistor circuits that comprise a gate must have connections to a voltage supply and to ground. For example, in the case of 74-series logic circuits used in this lab, the supply voltage (Vcc) must be 5 volts. In these integrated circuit packages, several gates are contained. Search Google specifying that gate number and its function (e.g. "7486 XOR gate") for pin connection diagrams, such as the pin diagram shown in Figure 1. You must have the pin diagrams for each gate you want to use, in order to do the following parts of Task 1. You can find pinout of rest of 74-series gates here: http://www.qsl.net/on7pc/datasheet/ttl7400/7400family.pdf. Other gates you need today are: 7408 quad 2-input AND, and 7432 quad 2-input OR.

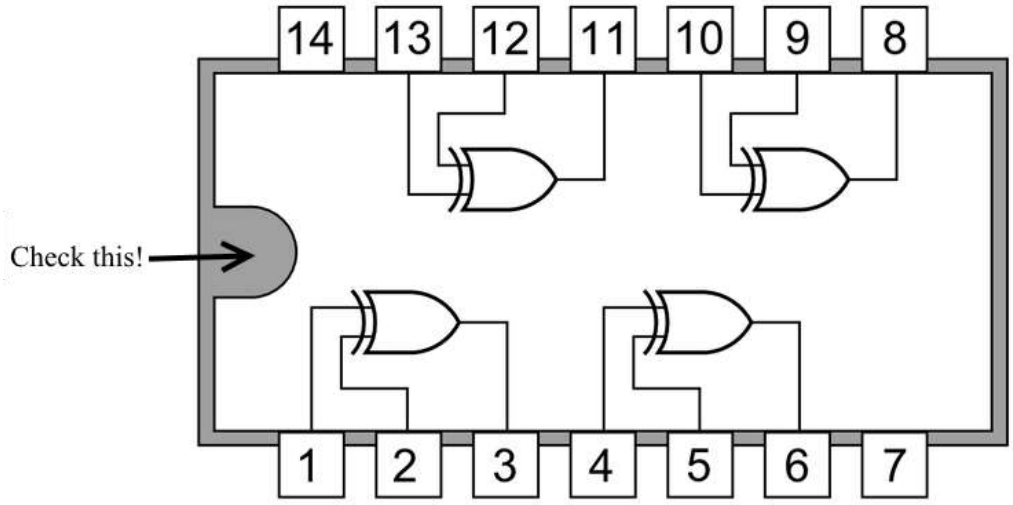

Fig 1: 7486 Quad 2-input XOR gates

1) Using the logic diagram in Fig. 2 (below) as a starting point, draw a *circuit schematic* of the digital circuit you will build. This should include **pin numbers** marked on the inputs and outputs of all the gates, **part numbers** (IC's code) of the IC package marked on each gate, plus **power and ground connections** marked on the side of the drawing. When you have drawn it, ask the TA or Tutor to come and check it. *Do not proceed to the next step until* you have verified that your circuit schematic is correct, and the TA or Tutor has approved it.

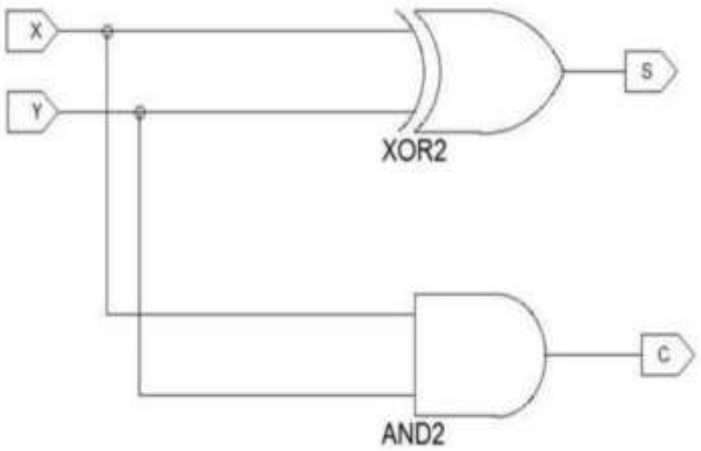

Fig 2: Half adder

2) Using your circuit schematic that you made in step 1, build the circuit step-by-step, following the Digital Circuit Suggestions given in Unilica and recommendations in page-1. Connect the inputs to switches on the logic board. Connect the outputs of your logic circuit to LEDs on the logic board. Don't forget to connect +VCC power and GND ground to the VCC and GND pins on both IC packages.

3) Make a test probe by connecting another LED on the logic board to one end of a long wire, whose other end will be used to touch circuit points and "see" the logic values. A full voltage level ~5 V will cause the LED to shine brightly; a 0 V level will not light up the LED. A low light output from the LED means that the voltage being sensed is in between logic 0 and logic 1, meaning something is WRONG with your circuit.

4) Now draw the truth table for the 2-input 2-output logic circuit that you have made, and fill in the left-hand (input) side in standard binary counting order. For each row, apply the input combinations by adjusting the switches, and measure the output. Use this information to complete the truth table, filling in the right-hand (output) side.

5) Compare your measured truth table that you just obtained from the circuit, with the below one. If there are no discrepancies, then it means that your logic circuit has worked as predicted. Ask the TA or Tutor to come and verify this. When the TA or Tutor has checked your circuit, you are done with this part.

A	B	C_{out}	S
0	0	0	0
0	1	0	1
1	0	0	1
1	1	1	0

Part 2: Understanding and Building a Full Adder (35 points)

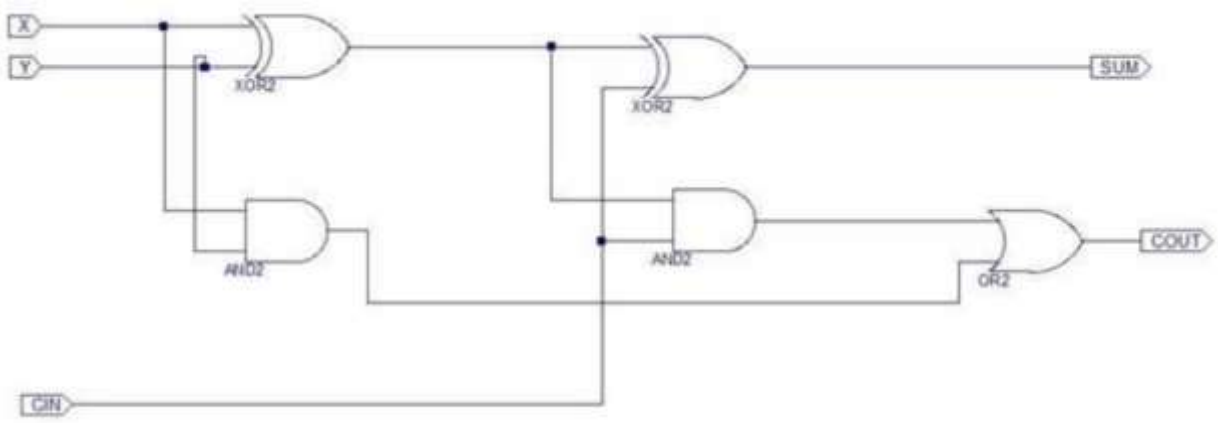

Fig 3: Full adder

1) In part 1 you implemented a half-adder, a circuit for adding two bits. Here you will do the same for a full-adder, a circuit for adding two bits and carry-in bit. As you did in part 1, convert the logic diagram into a circuit schematic by marking pin numbers, part numbers and power and ground connections. *Do not proceed to the next step until* you have verified that your circuit schematic is correct, and the TA or Tutor has approved it.

2) Using your circuit schematic, build the circuit, following the Digital Circuit Suggestions given in Unilica. Connect the inputs to switches on the logic board. Connect the outputs of your logic circuit to LEDs on the logic board. Don't forget to connect +VCC power and GND ground to the VCC and GND pins on all the IC packages.

3) As you did in Part 1, test and verify that your built circuit is working as a full adder, correctly producing the SUM and COUT outputs for each combination of X, Y and CIN inputs. When it is debugged and working correctly, ask the TA or Tutor to come and verify this. When the TA or Tutor has checked your circuit, you are done with this part.

C_{in}	A	B	C_{out}	S
0	0	0	0	0
0	0	1	0	1
0	1	0	0	1
0	1	1	1	0
1	0	0	0	1
1	0	1	1	0
1	1	0	1	0
1	1	1	1	1

Part 3: Clean Up

1) Clean up your lab station, and return all the parts, wires, the Beti trainer board, etc. Leave your lab workstation for others the way you would like to find it.

2) CONGRATULATIONS! You are finished with Lab #1 and are one step closer to becoming a computer engineer.

NOTES

--Advance work on this lab, and all labs, is strongly suggested.
--Be sure to read and follow the Policies for CS223 labs, posted in Unilica.

LAB POLICIES

1. There are three computers in each row in the lab. Don't use middle computers, unless you are allowed by lab supervisor.
2. You borrow a pack containing development baord, connectors.. at start. Lab supervisor takes your signiture. When you are done return it to her, otherwise you will be responsible and loose points.
3. Each pack has a number. You must always use same pack throughout the semester.
4. You must be in lab, working on the lab, from the time lab starts until you finish and leave. (Bathroom and snack breaks are the exception to this rule). Absence from the lab, at any time, is counted as absence from the whole lab that day.
5. No cell phone usage during lab. Tell friends not to call during the lab hours--you are busy learning how digital circuits work !
6. Internet usage is permitted only to lab-related technical sites. No Facebook, Twitter, email, news, video games, etc--you are busy learning how digital circuits work !