EECS203 Fall 2013
Lab 1: TTL Adder

1 Overview

For this laboratory assignment, you will implement a 4-bit adder with input and output using transistor-transistor logic (TTL). This lab is meant to be an gentle introduction to digital logic design and will teach you some skills that will prove useful in later assignments. You don't need to have a deep background in electronics to complete the lab; material covered in lecture should be sufficient. If you need help understanding some of the electrical concepts or just feel lost, please don't hesitate to contact course staff (especially your TA).

2 Implementation

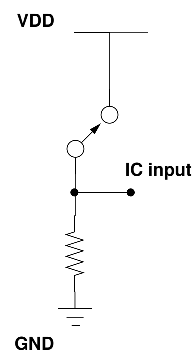
Digital adders are essential building blocks in modern electronics. In this lab, you will implement a small adder using a TTL component (7483). This integrated circuit (IC) is capable of adding two 4-bit binary inputs and generating a 4-bit sum and a carry. It does most of the hard-work for you. All you need to do is properly wire it up, build the right input circuit so that you can feed it values, and construct an output circuit so that you can display the result. This lab is intentionally easy so that you can get your feet wet. We're going to walk you through the whole process. We'll ask more of you in future labs.

First wire up all the VDD (red) and GND (blue) lines on your protoboard. Refer to the lecture notes if you are uncertain about how to do this. Power the board by connecting the power supply to the red and black terminals at the top of the protoboard. Verify that you have made the correct connections using the logic probe in your lab kit:

Make sure that the probe is set to TTL (not CMOS) and that the lower switch is set away from LATCH. Use the alligator clips to connect your probe to the red and black posts.

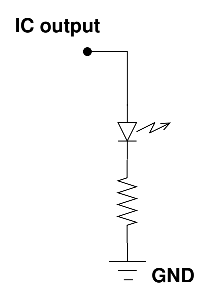
Now, pick holes adjacent to the red and blue lines and use the probe to make sure that they are properly connected. Don't directly stick the probe into the holes on the board...this can damage the board! Instead, grab a wire from your kit and place one end in the corresponding hole and touch the probe against the other end. Any soundly connected node should either give your logic probe a solid ON (Logic High) or OFF (Logic Low) LED output. If the output is flashing this means that the logic level is undefined (Note: It is not connected to anything. Recheck your wiring).

Wire up the input circuit. This will produce two 4-bit inputs and hence require a total of eight switches. This is the schematic diagram for a single switch:



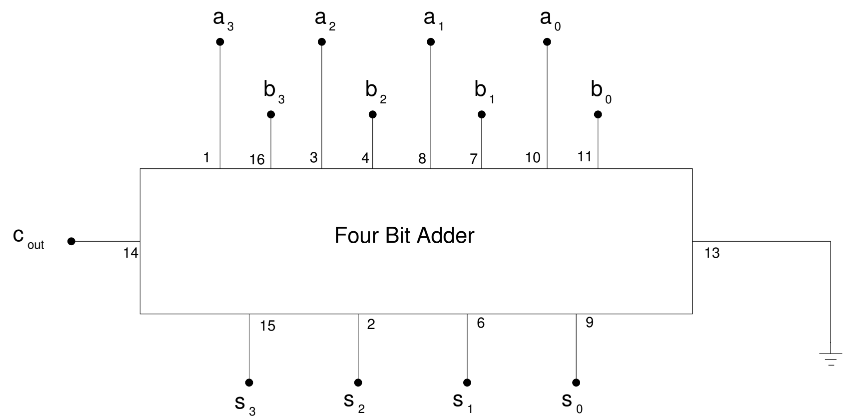
You'll need a few items from your parts kit: DIP switch, IC socket, resistor strip. The DIP switch is really a collection of 12 indepedent switches boxed up in one neat package. However, the DIP switch doesn't quite fit the holes in our protoboard, so we'll enlist the help of the IC socket to ensure that everything fits together snugly. Place the DIP switch in the IC socket and then seat the socket in the protoboard so that it straddles the grooves. Now, wire the top terminals of eight switches to VDD (we only need eight switches for this lab, leave the other switches for now). Wire the other terminals of the same eight switches to a resistor using the resistor strip. Remember that the resistor strip has one common terminal which should be connected to ground only. The remaining terminals should connect to the DIP. Once everything is wired to power and ground, you should have eight working switches. Verify that they are working using your probe. As you flip the switch between ON/OFF, the switch terminals near the resistor should either register Logic High or Logic Low (never undefined). These will be the inputs for your adder.

Now, wire up the output circuit. This will generate a 4-bit sum output and a single carry output. Here's a schematic diagram for a single output:



To implment this, we're going to use the LED strip, IC socket, and resistor strip. Place the LED strip inside the IC socket. Then place the IC socket on the protoboard so that it straddles a groove. Note that all LEDs are polarized devices, you need to identify the positive and negative terminals. With our LED strip, the side with positive terminals has a small notch in the corner. If you want the LEDs to light up correctly, make sure that you have the proper orientation. Connect the resistor strip to the negative terminals of the LED strip. Then connect the common terminal of the resistor strip to GND. For the time being, leave the other terminal of the LEDs unconnected...eventually they will be connected to the IC. You should test your LEDs to make sure that they are functional. You can indepedently test them by connecting them one at a time to VDD. They should light up brightly.

OK. You hopefully, have working input and output circuts at this point. This allows us to get to the real workhorse oh the lab...the 7483 Four-bit Adder IC. You should consult the datasheet for the IC..it's in the packet of papers that came with your lab kit (or you can look for a 7483 datasheet online). The datasheet describes the basic operation of the device including most importantly, the pin-out and truth table.



First wire up the 7483's VDD (or VCC) and GND (Pins 5 and 12 respectively) to your breadboard VDD/GND. Then following the block-diagram wire the remaining pins. Note that we are using a slightly different input/output notation than the datasheet. Once you are done, all pins of the 7483 should be connected to something. Double-check your wiring on more time.

Now, power up your board by plugging in the power supply. If you have assembled everything correctly, you should be able to use the input DIP switches to control the adder. Verify that you see the sum of the two inputs A + B on your output LED as well as the carry (5 bits total output). If the output doesn't match, double check your wiring. Subtle wiring mistakes can lead to nonsensical outputs. Document any tests that you perform, you'll need them for your lab writeup. If everything works, you're done. Save the working board and bring it in to your TA along with your completed report to receive credit for this lab.

When you're done with this lab, don't remove the wiring. You'll find that you can re-use much of it for the next TTL lab in a few weeks.

3 Write-Up

You should prepare a short laboratory report (1-2 pages). The report needs to fully document your project including major aspects of the design/implementation, validation, evaluation of the completed project, and anything you learned by building the circuits. Specifically, your report should contain the following components:

1. **Introduction/Objective** State the goals of the laboratory assignment and give a brief overview of the problem.

2. **Design Constraints/Requirements** Comment on any design requirements and document constraints that you will need to overcome to achieve your objective. What are the technical challenges?

3. **Broader Considerations** What is the broader impact of the design? What applications would this have in technology or wider society.

4. **Design Description** Present a detailed description of your design. Start with an overview and then discuss how individual sub-components are implemented and integrated. You should provide a complete parts list and diagrams sufficient for anyone else to reproduce your design.

5. **Performance/Validation** Describe how you tested your design. What steps did you take to make sure that it met requirements? Identify any limitations or shortcomings in your design.

6. **Conclusion** Summarize your design and report on to what degree it met requirements. Identify anything that you learned during the design process.

4 Grading

Note that color coding is not required for this lab, but we strongly recommend it since it will greatly simplify debugging efforts in future lab assignments. If you need extra wire, grab some from the large spools in the teaching lab.

Correct input/output assembly	4
Functioning circuit	9
Layout style and neatness	2
Report quality	5
Total	15