University of Utah
Electrical & Computer Engineering Department

ECE 1250 Lab 6

Digital Logic (Adder)

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rev,

Note: Bring textbook & parts used last time to lab.

Objective

To learn a little about combinational logic by constructing a 2-bit binary adder.

Parts to get from a bin by the checkout window:

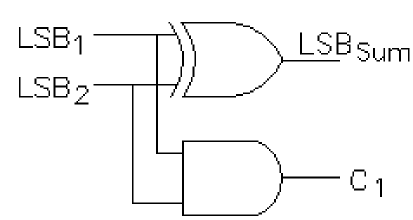
- DIP switches (Little blue boxes with 7 white switches per box)
- Any other parts listed below that you can find there

Parts to be supplied by the student:

- 74LS08 quad 2-input AND gate IC (Integrated Circuit)
- 74LS86 quad XOR gate IC
- 3 270 Ω resistors (Red Violet Brown)
- 3 1N914 or 1N4148 small signal diodes (you may already have 2)
- 3 LEDs (Light Emitting Diodes)
- Breadboard and wires

Background (binary number addition)

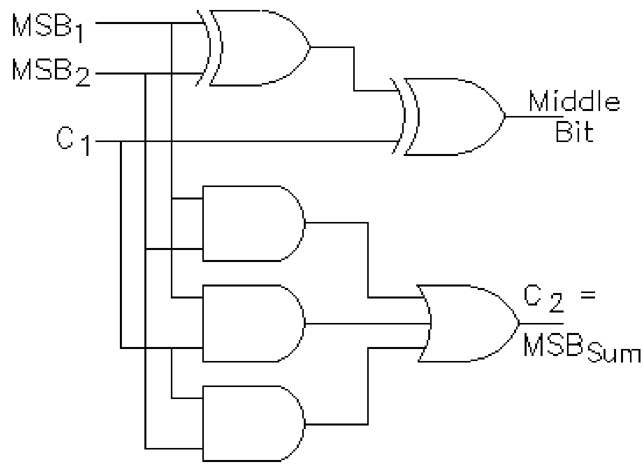
Read about binary numbers in chapter 12 of your textbook and especially how binary numbers are added to one another on page 636. In this lab you will be building a 2-bit binary adder. The inputs will be 2 2-bit binary numbers (4 total bits) and the output will be a 3-bit binary number, the sum. Each 2-bit binary number will have a most-significant bit (MSB) and a least-significant bit (LSB) with no additional bits in between. (Most binary numbers will have lots of bits in between.) First, you will construct a circuit which will add the 2 LSBs together to get the LSB of the sum and possibly a carry bit. This circuit is known as a "half-adder". Next, you will construct another circuit which will add the next 2 digits (the 2 MSBs in this case) along with the carry bit to get the next digit of the sum and possibly another carry bit. This circuit is known as a "full-adder". Since there are no more stages, this carry bit becomes the MSB of the 3-bit output. To add 2 x-bit binary numbers you would need to have 1 half-adder and x-1 full-adders. As always, provide some background information in you lab notebook.



Make a truth table of the half-adder showing the 2 LSBs as inputs and 2 outputs, the LSB of the sum and the first carry bit. Will the circuit shown do the job? If yes, you may use it. Draw the circuit in your notebook like you always do.

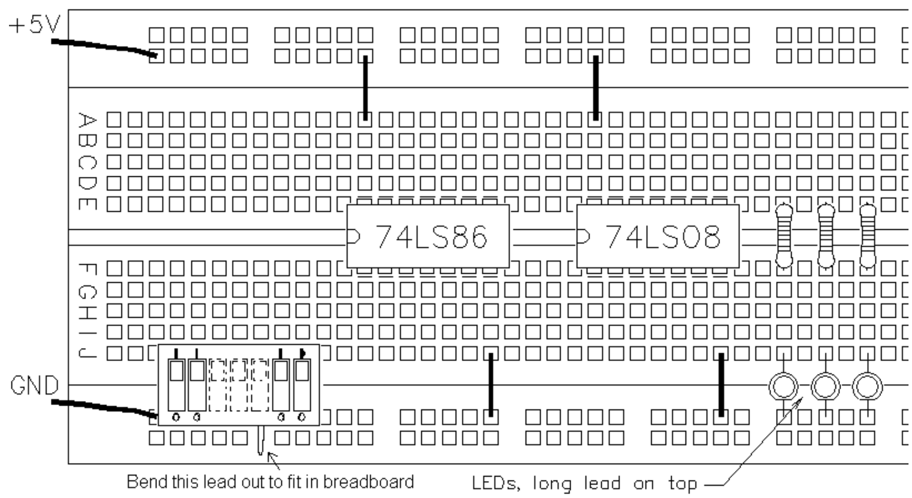
Make a similar truth table of the full-adder showing the 3 inputs and 2 outputs. The full-adder can actually be looked at as two separate circuits. Confirm that the next circuit shown will act as a full adder or design a circuit of your own.

Could the full adder circuit be repeated as many times as necessary to make any size adder?



Experiment

Place your parts on your breadboard. A suggested placement is shown, but you may place them however you like. Individual part pinouts are shown on page 641 of the text. The positive supply pin of the IC is labeled Vcc and the negative supply is ground. Make the power connections to the ICs.



Set the bench power supply to 5 V (either the 6 V or the 25 V supply will do). It would be wise at this point to hit another supply button on the HP/Agilent so that accidentally turning the knob will not affect your 5 V setting and fry your ICs. Turn the output off and connect the supply to your breadboard.

The DIP switch will serve as your inputs. I suggest using the left 2 switches as 1 binary number and the right 2 as the other. The switches work like those shown on p. 631 of your text. We can get by without the 10 kΩ pull-up resistors because the ICs that we are using have internal pull-up resistors. (The inputs are said to “float high”.) This is actually very bad design practice but will work in our case and keeps our part count down. If these inputs give you problems later, add the external 10 kΩ pull-up resistors. You may still have these resistors from an earlier lab.

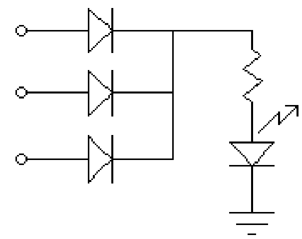
3 LEDs (Light Emitting Diodes) will serve to display the output bits of the sum. Each should be connected in series with a 270 Ω “dropping” resistor. The ICs we are using can supply this combination directly, without additional amplifiers, drivers, or buffers. Be sure to wire the right-most LED as the LSB of the sum and the left-most as the MSB.

Connect and Test the Half-adder

At the end of this lab you will find some drawings showing the DIP switch, the ICs, and the output LEDs with resistors. These drawings are provided to help you plan and draw the wiring of your circuits. Cut one of these out and draw all the wires needed to make the half adder. The switch outputs may be wired directly to the IC inputs and the IC outputs may be wired directly to the resistors. When you are satisfied that your drawing is correct and complete, tape it in your notebook and use it to help you wire the actual circuit. Temporarily wire the carry bit to the center LED for testing purposes. Turn on the power and test your half adder using the truth table you made earlier. If you need to make changes to your circuit change your drawing to match. Disconnect the power and remove the temporary carry-bit wire when you've confirmed the circuit works correctly.

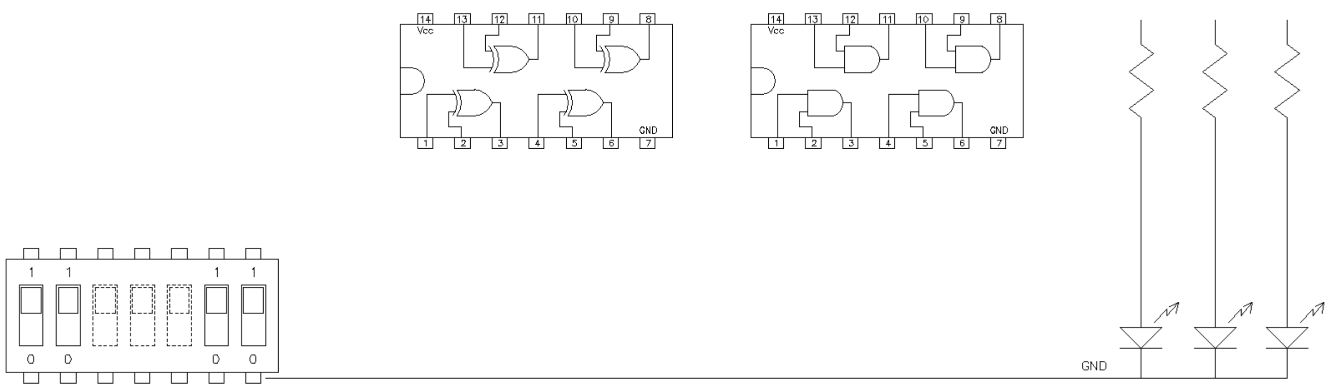
Connect the Full adder and Test the Entire Circuit

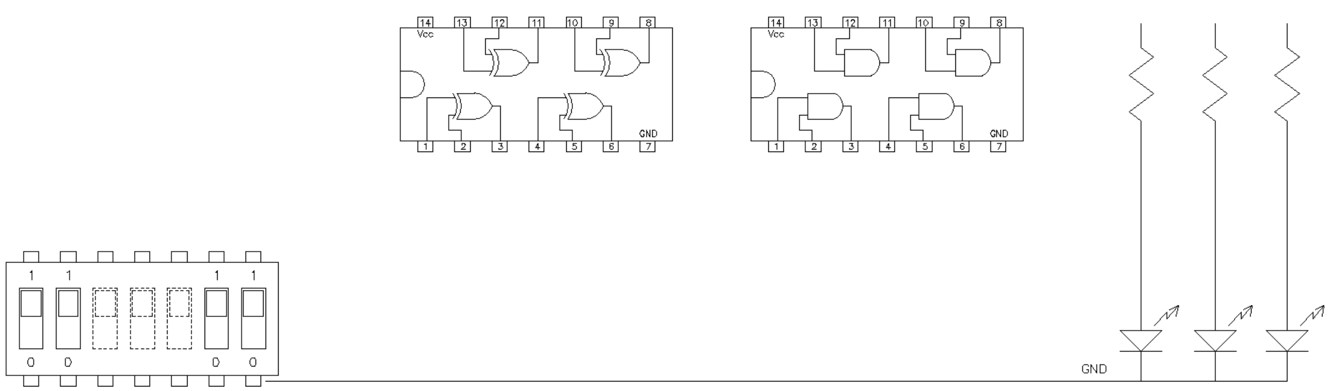
Repeat the above procedure to plan and wire the full adder. You may add lines to your existing drawing or start with a new drawing. On a new drawing, you may add just the new wires or draw them all, whatever works for you.



Now you're going to run into a problem– there's no OR gate! Ahh, that's where the diodes come in, we're gonna cheat and make an OR gate out of 3 diodes, as shown. It's a little bit cheezy, but, as Frank Zappa says, it's nicely displayed.

When you are satisfied that your drawing is correct and complete, tape it in your notebook and use it to help you wire the actual circuit. Connect the power and test your full circuit





using the truth tables you made earlier and/or your understanding of binary addition. If you need to make changes to your circuit change your drawing to match.

When your circuit works properly, call over your TA. Your TA will give you some numbers to add and you will demonstrate your adder. Make sure your TA checks off your notebook.

Conclusion

Real adders are not made with individual ICs anymore. In fact these logic ICs are rarely used for anything anymore. You can now buy a whole computer on an IC smaller than any you used today and it will do much, much more and use less power to do it. Nevertheless, this is still a worthwhile exercise since these computers, which contain adders, are designed by... you guessed it... Electrical and Computer Engineers.

Conclude as always. Make sure everything is off. Return the DIP switch to the bin by the checkout window and leave whatever other parts you don't want to keep there as well.