

Lab 0: HCMOS Logic Family

Introduction

In this lab you will get a hands-on experience designing simple logic circuits using standard DIP format integrated circuits (ICs). You will learn about timing and its effect on the circuit output.

1 Prelab

- 1.1. Write the truth table for an *inverter* gate.
- 1.2. Write the truth table for a 2-input *XOR* gate.
- 1.3. Write the truth table for a 2-input *AND* gate.
- 1.4. Write the truth table for the circuit shown in Figure 1.
-Hint: What happens with an even number of inverters? What about odd?

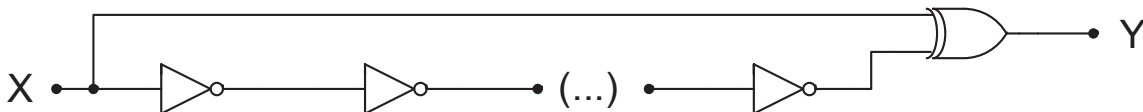


Figure 1: A Simple Circuit

- 1.5. For the following logic statement, create a K-map:

$$f(x_1, x_2, x_3) = x_1x_2x_3 + x_1'x_2x_3 + x_1x_2x_3' + x_1x_2'x_3' + x_1'x_2'x_3'$$
- 1.6. Simplify the equation using the K-map technique.

2 Lab

2.1 Basic Behavior of HCMOS Logic Family

- 2.1. Use the datasheet to connect a 7404 IC.
- 2.2. Connect one input to GND and check that the respective output is a logic 1 using the logic probe. Afterward, connect the input to VCC of 5 V and check that the output is now a logic 0.
- 2.3. Use a variable 10k Ω potentiometer to vary the input to the inverter, as shown in Figure 2. The potentiometer is the blue component with a white knob on top. The knob will only turn around 2/3 of a full rotation and is used for coarse adjustments. **Using a voltmeter, measure the voltage output of the potentiometer. At what point does the output of the inverter change?**

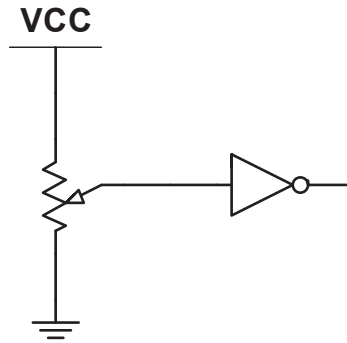


Figure 2: Changing the input to the inverter

- 2.4. Build the circuit shown in Figure 1 using 10 inverters in series. Using the protoboard, set the function generator to 100 KHz. **Can you observe the output of your circuit by using a voltmeter or logic probe?**
- 2.5. Connect the output of your circuit to the logic analyzer and record your observations. (Use the information provided in Section 3 to run the logic analyzer).
- 2.6. Does the output match what you expected? Why or why not?
- 2.7. What is the propagation delay of an inverter gate?

2.2 Half Adder

- 2.1. **Write the truth table for the circuit shown in Figure 3.**

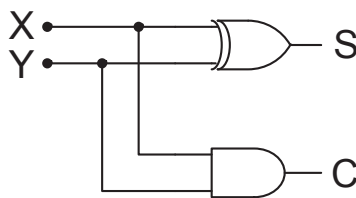


Figure 3: Half Adder Circuit

- 2.2. Connect ICs from the 7400 IC to implement the circuit shown above.
- 2.3. Verify the operation of the circuit by connecting the inputs to different combinations of Vcc and GND.
- 2.4. **In terms of binary arithmetic, what do the S and C outputs represent?**

3 Supplement: Logic Analyzer - Saleae Logic 8

3.1. Installing Logic Analyzer software on personal computers:

- Visit Saleae.com for the logic software download.
- Install logic program on to your operating system, following prompts.

3.2. Start the Logic Analyzer by opening the program 'Logic 1.2.xx' in the start menu. Do the following:

- Connect the Saleae Logic 8 analyzer via the USB port.
- Open the Logic 8 settings by clicking the green arrows next to the start button.
- Deselect ch. 2 - 7 for both digital and analog readings only selecting ch. 0 - 1.
- Set the sample rate to 25 and 10 MS/s (Mega samples per second).
- Lastly set the desired run duration you wish to be analyzed.
- Click on the Start button near the top of the window. The logic analyzer will sample the logic levels on lines 0 and 1.

3.3. Observe the Waveforms. You can use the scroll wheel to zoom in and out. **Does the waveform make sense to you? Why are there two separate outputs for each channel? Explain.**

3.4. Print a sample of the waveform, and put it in your lab notebook.

- To print a copy of this waveform, use the windows snipping tool, opening it from the start menu.
- Click new snip, and drag a box around the part of the waveform you wish to save.
- **Hint:** to create a printer-friendly version, open Paint, open snip, select all, right click, and select invert colors.
- You can now paste this image into Word which will make it easy to print out.

3.5. Another way of displaying logic data is as numbers. Click on the Options menu at the top right, under Display radix select Bin. This will show the binary data outputs, and you can also switch to Hexadecimal, Ascii text, or other formats. (you can save this data to a text file (.csv) by clicking export data) **How does this numeric data compare to a truth table format?**

3.6. **NOTE:** If the Saleae Logic program does not connect properly, it will remain in 'simulation mode', which will output a sample logic output signal.

3.7. **NOTE:** Saleae Logic is not a perfect program. Disconnecting the logic analyzer or pulling the USB cable will cause the program to auto-exit. Please save your work frequently. **DO NOT WAIT UNTIL THE END TO PRINT YOUR RESULTS.**