LAB 3

Laboratory Report for CS 2420

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*Abstract* – This lab assignment served as an introduction to voltage threshold, gate delay, and propagation delay. We built several circuits and used the function generator and oscilloscope to create and measure several different functions. I learned a lot about how the delay in an electronic circuit must be accounted for and how they can be measured.

# Introduction

Today’s lab revolved around the concepts of propagation delay and voltage threshold. These concepts are pivotal to deeper understanding of electrical circuits and digital logic. Propagation delay must be understood in order to ensure the correct signals are producing the correct results in a digital circuit. Threshold voltage is important to understand because it is literally the difference between on and off and the exact voltage where that transformation occurs. Finally, we compared our recordings of propagation delay in a circuit to the expected value for that delay.

# Experimental Method



To begin the project, I supplied power and ground to the 7404 chip (pictured above) on my Elvis board. I then connected pin 1A to the Variable Power Supply and connected pin 1Y to LED 0. Using the VPS option from the Elvis instrument bar, I made sure the voltage supplied was 0 and I recorded the state of the LED.

I then began to increase the power slowly from 0v to 5v, making sure to note and record the voltage at which the LED either flickered from light to dimmer or from dim to lighter. These voltages were recorded as the threshold of 0.

Next I connected pin 1A to the variable power supply (VPS), pin 1Y to pin 2A, and pin 2Y to LED 0. I then set the supply to 5V and recorded the status of LED 0.

I then repeated the procedure of increasing and decreasing the voltage in order to find and record the voltage threshold for logic 1 for this circuit.

Next, I created the following circuit:



Pin 1A was connected to the function generator, 1Y was connected to AI0+ and 2Y was connected to AI1+ and AI0- and AI1- were connected to the ground. At 100khz for the frequency, 2.5v for the amplitude, and the rectangle option for wavelength, I used the function generator to alternate from 1 to 0 and I recorded the wavelengths with the oscilloscope. On the oscilloscope, channel A was AI0+ for source, 2V/div for the scale, zero for position and DC for coupling. For channel B, everything was the same as channel A except AI1+ was chosen as the source. I then recorded the results from the oscilloscope. My oscilloscope did not seem to be functioning properly, but I recorded the results and the expected results nonetheless. I also recorded how the wavelengths would look if there was 0 delay.

Finally, I modified the circuit to look like the following:



Essentially, I added a resistor and a capacitor (that goes to ground) to the circuit. I used the formula for propagation delay to calculate the expected value, then used the circuit to record the actual delay.

# Results

For the first procedure, the results are in the following table.

Before I began increasing and decreasing the voltage, the LED 0 was on because the low voltage (0v) is being “notted” by the 4304 gate into a true reading (LED on).

|  |  |  |  |
| --- | --- | --- | --- |
| Change the Input | When Increasing | When Decreasing | Min (X0, Y0) |
| Threshold of 0 | X0= 1.03 | Y0 = 0.93 | (1.03, 0.93) |

After this procedure, the next procedure (same thing but “notted” twice) produced the following results:

With a supply of 5V, the LED remains on because it is being negated twice, and double negation returns the original condition (5V). The remaining results were:

|  |  |  |  |
| --- | --- | --- | --- |
| Change the Input | When Increasing | When Decreasing | Max (X1, Y1) |
| Threshold of 1 | X1 = 1.25 | Y1 = 1.06 | (1.25, 1.06) |

Next, I moved on to “Understanding gate delay in a logic gate.”

Because my Elvis board was malfunctioning during the lab (I believe there was at least one short in either the wire or the board), I was not able to obtain the correct results. The correct results should look like the following:

Unfortunately, mine looked like this:

If there were absolutely no delay, the oscilloscope would produce results similar this this:

(The increasing and decreasing portions would overlap entirely.)

From the oscilloscope, the measured delay was 2 us.

Finally come the results from the final portion of the lab. For my expected delay, I calculated resistor ® times capacitor ©. R=10 ohms while 10 pF. Therefor total delay = (1\*103) \* (1\*10-6) = 10-3 ms. The reading produced by the oscilloscope and function generator was 2.64 ms. The waves should have formed the following pattern on the oscilloscope:

# Conclusion

In conclusion, this lab served as an excellent introduction to both propagation delay and voltage thresholds. Although some of my results involving the oscilloscope were incorrect, this is to be blamed on faulty equipment rather than faulty design, as my circuit design was approved by an instructor. However, understanding the results that should have been achieved is imperative to understanding the underlying concepts in this lab.

# References

*No references were used (other than handouts) in the creation of this laboratory report.*