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Lab 11: Digital Circuits

Introduction

The purpose of this lab was to use digital circuits to compare to expected truth tables that were discussed in class. The type of digital circuits analyzed were TTL, which require 5 V (Gannett, lab handout, 2019). This lab consisted of three different sections: investigating logic gates, investigating the J-K flip flop, and learning about the 555 chip. Due to lack of time, the third section was not able to be completed. For the first section of the lab, a NAND gate on the 7400 chip and a XOR gate on the 7486 chip were analyzed. Figure 1 displays the pin and circuit set up for the 7400 chip. Figure 2 displays the pin and circuit set up for the 7486 chip. Lastly, two 7476 chips were used to create counter circuits in which one light turns on at a time.

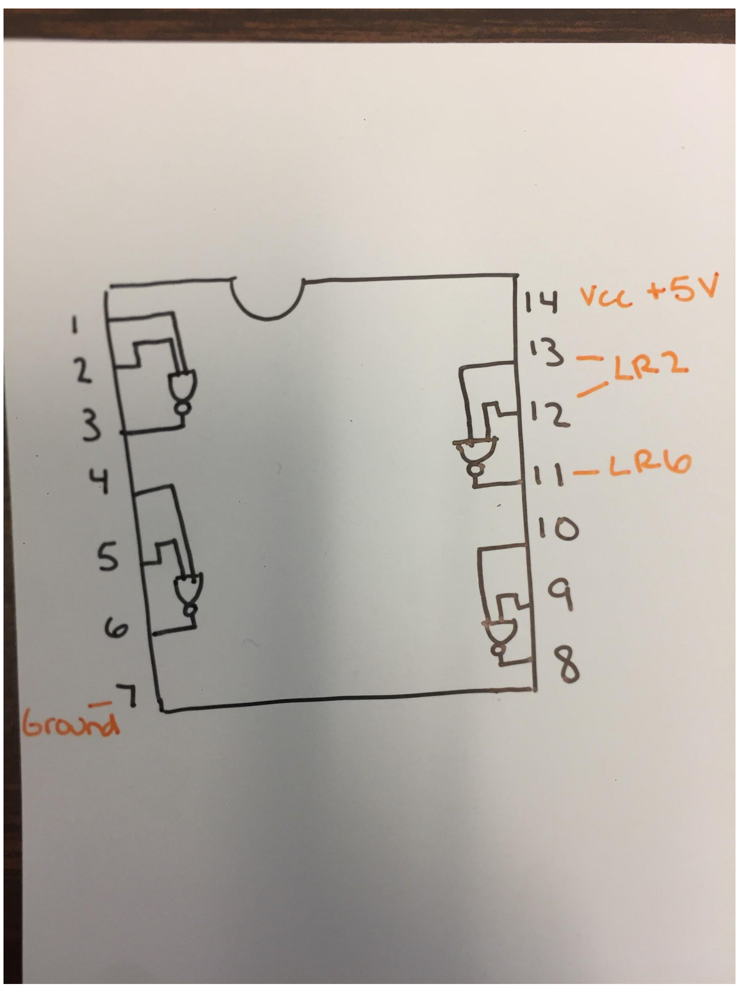

Figure 1. Circuit schematic with the 7400 chip.

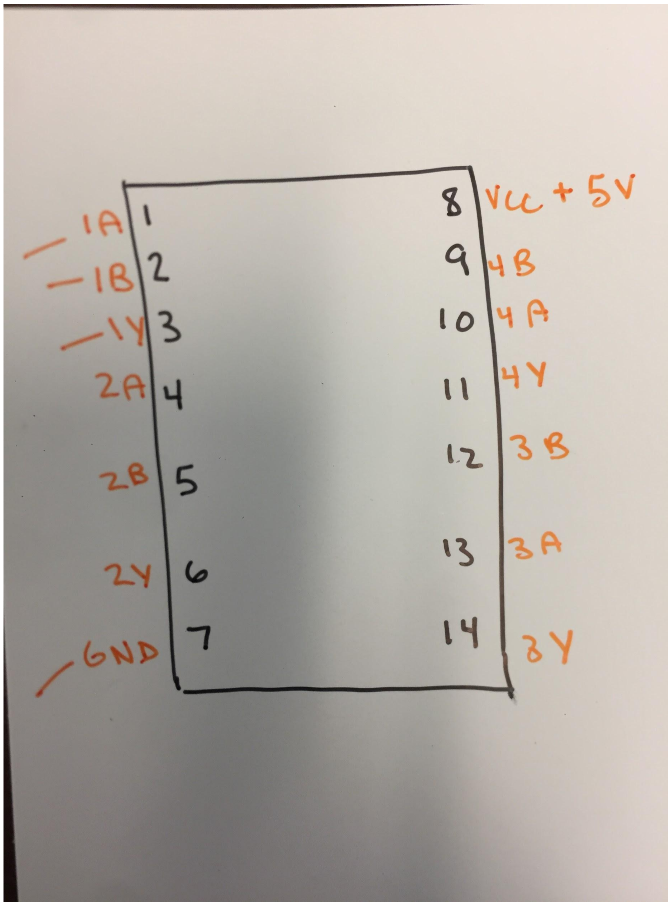

Figure 2. Circuit schematic with 7486 chip.

Methodology

Digital signals come from a binary system. The input/output is either high or low. Outputs are determined based on the internal gates of the chips used in the analysis. The different types of gates include NOT, NOR, AND, NAND, and XOR. A gate can be described as an amplifier circuit that takes in and outputs binary signals (All about circuits n.d.). Truth tables can be constructed with every scenario of input and output. These tables give an idea of what the output will be with the given possibilities of inputs.

Results and Discussion

Table 1. Truth table for the NAND gate chosen in the 7400 package.

A	B	Not A AND B
1	1	0
0	1	1
1	0	1
0	0	1

Table 2. Truth table for the XOR gate chosen in the 7486 chip.

1A	1B	1Y
1	1	0
0	1	1
1	0	1
0	0	0

Table 3. Truth table for the J-K flip flop using a 7476 chip.

Pre	Clr	J	K	Q	Qnot
L	H	L	L	H	L
H	L	L	L	L	H
L	L	L	L	H	H
H	H	L	L	Qo	Qo not
H	H	H	L	H	L
H	H	L	H	L	H
H	H	H	H	toggle	toggle

The NAND gate outputs high only when both inputs are low, and the XOR gate outputs high if one input is high and the other is low. As shown in the truth tables above, our observations matched our predictions exactly.

With four inputs, the truth table for the J-K flip flop is more complex. The preset and clear inputs are able to override the J and K inputs; when the preset is low, the output is high, and when the clear pin is low, the output is low (assuming the preset is not also low). When we constructed our counting circuit, the clear input allowed us to reset the count to 0 at any time.

If both the preset and clear pins are high, the chip's output is controlled by the J and K inputs. Setting both pins to low simply maintains the output at its previous value. Setting J high and K low makes the output high, while setting J low and K high makes the output low. Finally, setting both inputs to high causes the output to toggle between low and high at the start of each clock cycle.

The clock input was driven manually using a debounced switch. Switches on their own produce a noisy signal as the connection between the contacts is made and broken; as a result, the noise can cause the counter to register several clock cycles with every flip of the switch. Debouncing smooths the waveform and ensures that each flip of the switch corresponds to only a single cycle.

Unfortunately, we ran into technical problems while building the counter circuit, and we were unable to make a functioning 4-bit counter and produce graphs of the output. We were at least able to get the first half working, and we observed the first two LEDs count four numbers, specifically 0, 1, 10, and 11.

Conclusion

In this lab we explored digital circuits, which are circuits in which the signal has only two states: high and low. We began by verifying the truth tables for the NAND and XOR gates on the 7400 integrated circuit. After that, we verified the truth table for a J-K flip flop, which was much more complex. Finally, we attempted to construct a 4-bit counter, using LEDs to represent binary digits. We were unable to make the entire circuit function correctly, but we managed to create a 2-bit counter and observed it counting four numbers.

References

"Digital Signals and Gates." (n.d.). *All About Circuits*, <https://www.allaboutcircuits.com/textbook/digital/chpt-3/digital-signals-gates/> (May 3, 2019).