Lab 3: Combinational Logic Circuit

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Name: Orkun İbrahim Kök

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Purpose

The purpose of this experiment is to get used to how to use a breadboard with some other external components which are “74HC163 4-bit counter and some74 LS/HC circuit components (gates)”. The aim is to create a combinational logic circuit without using a Basys3 FPGA.

Design Specifications

The logic circuit design that I created has 3 inputs (A, B, and C) and 1 output (Y). Getting the inputs from the 74HC163 4-bit counter, I inverted the A input and then take all 3 inputs to an AND gate.

A’BC = Y

Methodology

The main character of the experiment is 74HC163 4-bit counter, therefore, first I added it to my breadboard. Seen in the Figure 1, it has 4 input ports, which are D_0, D_1, D_2, and D_3. I am going to use only 3 of them because my logic circuit has only 3 inputs (D_0 as A, D_1 as B, and D_2 as C). Then I will connect my LEDs to these inputs in order to observe how my logic circuit is working. After that, from the list, I took 1 triple-input AND gate (74 LS/HC 11) (Figure 2) and 1 hex-inverter (74 LS/HC 04) (Figure 3). Then I connected the A input to the hex-inverter and obtained A’. Consequently, I took all three inputs A’, B, and C to triple-input AND gate and get Y = A’BC, and lastly, I connected 1 additional LED to the Y output. Aftering being done with input-output connections, I connected the ground inputs (GND) of the 74HC163 4-bit counter, AND gate (74 LS/HC 11), and hex-inverter (74 LS/HC 04). Following, I connected the clock input of the 74HC163 4-bit counter to power supply and V_{DD} ports to power supply.

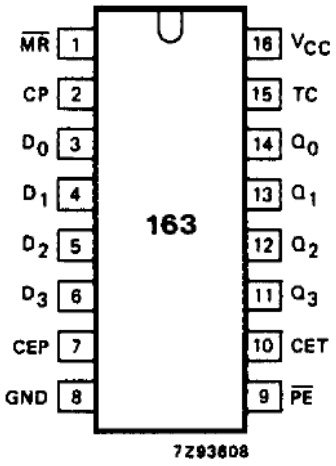

Figure 1: 74HC163 4-bit counter

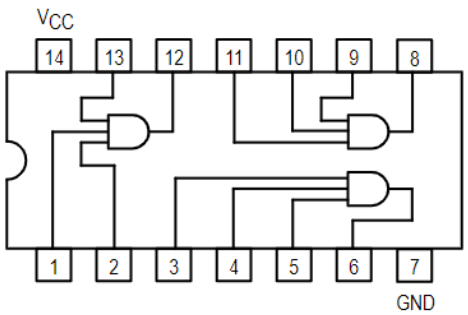

Figure 2: 74 LS/HC 11 triple 3-input AND gate

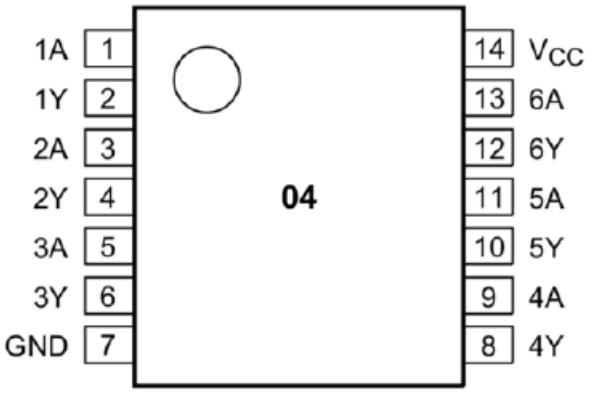

Figure 3: 74 LS/HC 04 Hex-inverter

LED A	LED B	LED C	LED Y	A	B	C	Y
1	1	1	1	0	0	0	0
1	1	0	1	0	0	1	0
1	0	1	1	0	1	0	0
1	0	0	0	0	1	1	1
0	1	1	1	1	0	0	0
0	1	0	1	1	0	1	0
0	0	1	1	1	1	0	0
0	0	0	1	1	1	1	0

Figure 4: Truth Table

Results

First of all, because LEDs light up on LOW voltage level, the actual inputs A, B, and C can be seen as inverted logic of corresponding LEDs. At the end of the experiment, comparing the results that are obtained both from the truth table and oscilloscope (Figure 5), as expected, the results are the same. Using an oscilloscope, I observed waveform of my inputs one by one. First, given 1kHz signal frequency to 74HC163 4-bit counter, I obtained a waveform with 0.125 kHz signal frequency for A input (Figure 7). For the B input, I obtained a waveform with 0.250 kHz signal frequency for B input (Figure 8), and finally, I obtained a waveform with 0.5 kHz signal frequency for C input (Figure 9). Ultimately, I did the same procedure for the Y output, given 1kHz signal frequency to 74HC163 4-bit counter, I obtained a waveform with 0.125 kHz signal frequency for Y output (Figure 10).

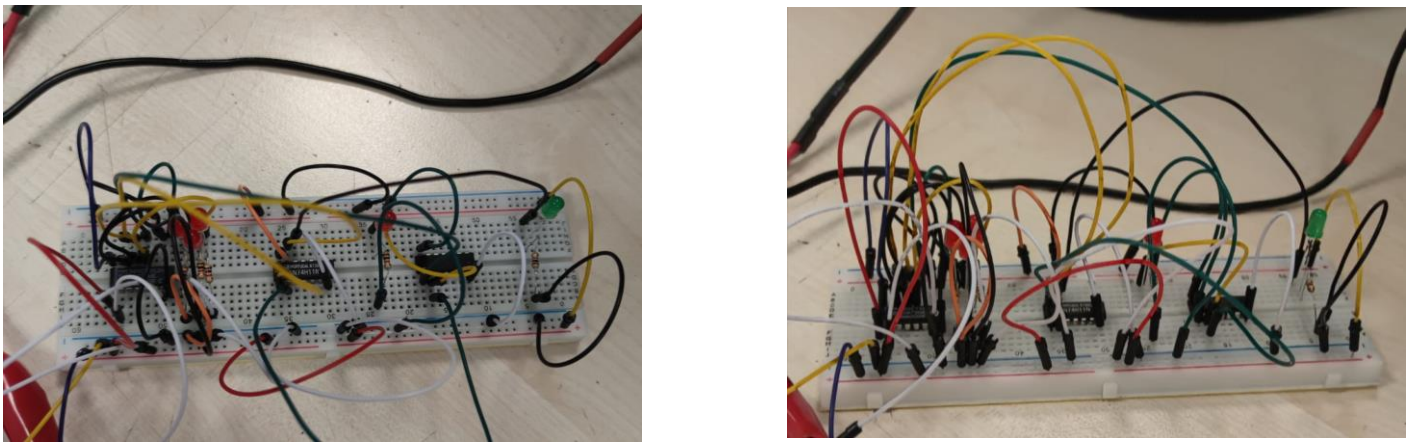

Figure 5: Circuit on breadboard

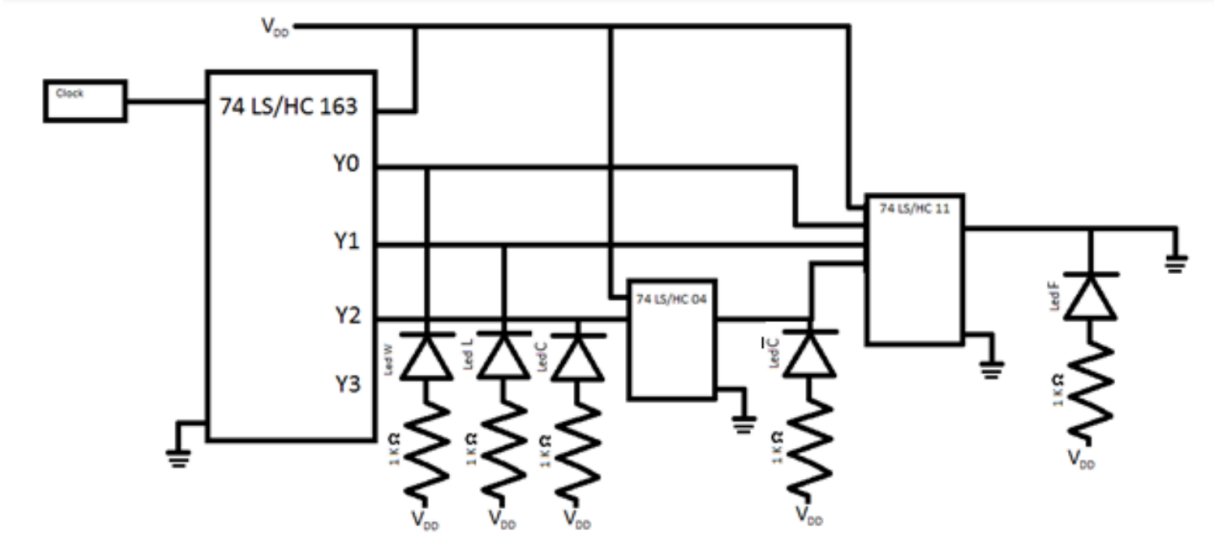

Figure 6: Simplified version of the logic circuit

Figure 7: Waveform of the A input with 125 Hz (1kHz signal given to 74HC163 4-bit counter)

Figure 8: Waveform of the B input with 250 Hz (1kHz signal given to 74HC163 4-bit counter)

Figure 9: Waveform of the C input with 500 Hz (1kHz signal given to 74HC163 4-bit counter)

Figure 10: Waveform of the Y output with 125 Hz (1kHz signal given to 74HC163 4-bit counter)

Conclusion

The purpose of the experiment is creating a combinational logic circuit on a breadboard using a 4-bit counter and some logic gates. The experiment has reached its aim because the oscilloscope and truth table values resemble each other. Which, what I was expecting to see.