Ege Ozan Özyedek
Lab 03 – Experiment 03
EEE102 – 02
17.10.2018

- Design Specification Plan

  In this experiment, a scenario which created various possibilities of binary inputs was used to implement a logic circuit on a breadboard using various IC's. There are three inputs; H (help), A (analysis)and S (supply). The output is P (production). H represents a helping manufacturer and A and S represent problems. P represents the production delay; so, if P = 1 the production is delayed and if P = 0 the production is on time. To further understand the relation, the truth table and the logic gate design can be found below.

Table 1: Truth Table of the Assembled Circuit

S	H	A	P
0	0	0	0
0	0	1	1
0	1	0	0
0	1	1	0
1	0	0	1
1	0	1	1
1	1	0	0
1	1	1	1

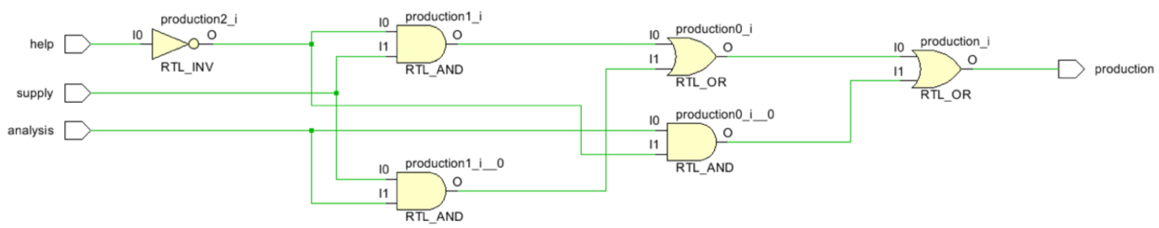

Figure 1: The Logic Circuit Diagram

To implement this relation on hardware, the following resources are nedded.

- A breadboard
- Jumper cables
- Different IC's with different capabilities
  - 74HC/LS163, 4-bit binary counter: A counter which takes a square wave and outputs 4 different outputs, in this case these outputs were the binary variables.

        - 74HC/LS04, Inverter: An inverter which inverts the input. Only one input pin will be used.
        - 74HC/LS08, Quad 2-input AND-gate: This IC has four 2-input AND-gates inside it. Only three of these four gates will be utilized.
        - 74HC/LS32, Quad 2-input OR-gate: This IC has four 2 – input OR-gates. Only two of these will be used to create the same output of a 3-input OR-gate.
    - 4 LEDs; 1 for the output and 3 for the starting variables
    - 4 1kOhm resistors for the LED connections.

The assembly of the circuit starts by first putting the IC's on the middle of the breadboard. This helps us in easily connecting the output, input, ground and voltage pins. I decided to put the clock first, then the inverter, AND-gate and OR-gate. Then all of the V_{CC} pins of IC's were connected to the (+) part of the breadboard with jumper cables. Then the same procedure happened with the ground pins, all of the ground pins were connected to the (-) side of the breadboard with jumper cables. Then I proceeded to connect the MR pin of the counter to the 5V voltage. After the connections of the IC's are done, the next step is to set up the LED's. The first three LED's are indicators of the three binary variables and the fourth is the output indicator. First, we set up the variable indicators by connecting the output from the counter (163) to a 1kOhm resistor. Then we connect the resistor to the (+) side of the LEDs and connect the (-) side of the LEDs to the (-) side of the breadboard. The same connections are also applied to the output LED; however,
the 1kOhm resistor is connected to the output of the final OR-gate in the case of the output LED. When the LED's are set, it's time to implement the logic part of the circuit. The pins schematics of the IC's will be down below for names of pins and general context.

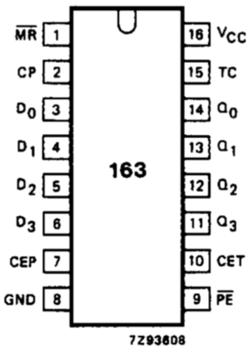

Figure 2: The 4-bit counter

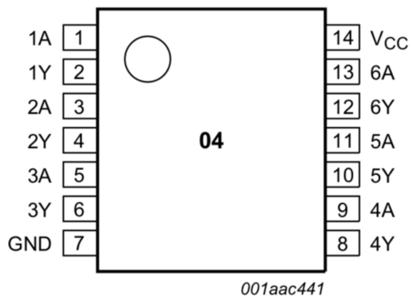

Figure 3: The Inverter

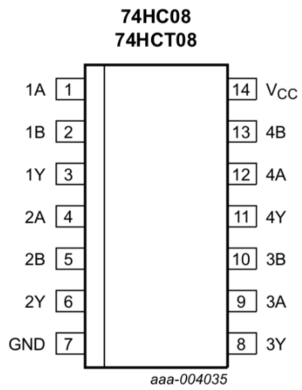

Figure 4: The AND-gates

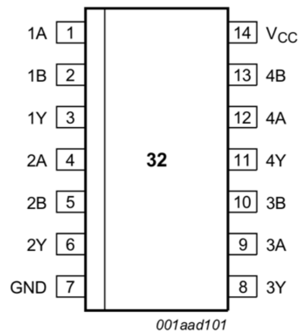

Figure 5: The OR-gates

The assembly starts by first inverting the Q_0 output from the counter, this will be H. Then Q_0 is connected to *6A*. The output from the inverter, $\overline{H}$, is obtained from *6Y* and connected to two different AND-gate inputs: *3B* and *4B*. The H inputs connections are done. The next outputs connected are S and A. These two are very similar in connection so I will proceed to explain both at the same time. Q_1 is S and Q_2 is A and both will be directly connected to the AND-gate. First, they are connected together at an AND gate, S being connected to *1A* and A being connected to *1B*. Then both will be connected with the inverted H, S to *4A* and A to *3A*. Then the first two outputs form the AND-gates will be connected to the OR-gate, *3Y* and *4Y*. Then the output of this OR-gate will be connected to another OR-gate with the final AND-gate, *4Y* from the OR-gate to *1A* and *1Y* from the AND-gate to *1B* of the OR-gate. Finally, 3 jumper cables with open ends were placed to the CP pin of the counter, the (+) side of the breadboard and the (-) side of the breadboard. To power the circuit and observe the possibilities, the jumper connected to the clock should be connected to the signal generator (which will generate a 1Hz square wave) and the ground of the generator should be connected to the jumper on the (-) side of the breadboard. Then the voltage supply should be connected to both the (+) and (-) side of the breadboard. The voltage supply will supply 5V to the breadboard. The circuit itself can be viewed on the figure below.

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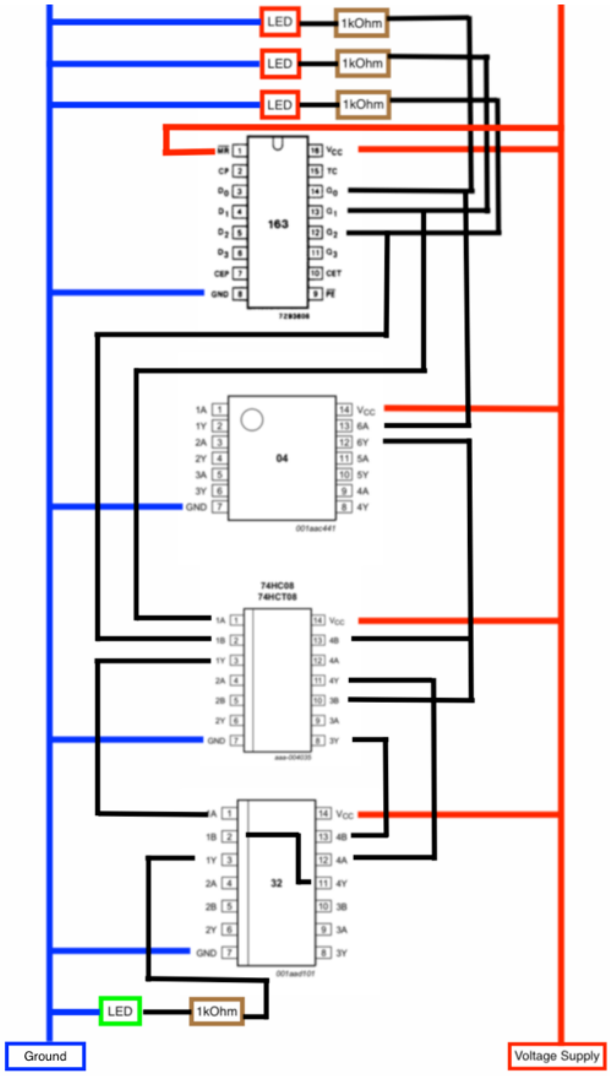

Figure 6: The Circuit Diagram

- Results

The results were as expected on the final circuit, although there were some problems along the way. There were many times where the circuit wouldn't detect the square wave or there would be other problems because of the jumper cables (I had to use a long jumper cable wire and had to cut them which would result in the cable sometimes breaking). These problems at times caused the results to vary but at the end the true results were met. Below the results can be observed.

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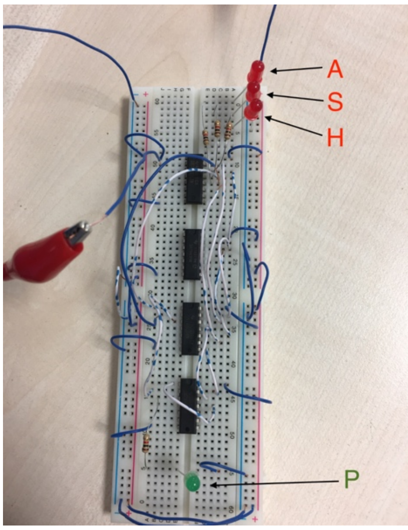

Figure 7: H:0 S:0 A:0 P:0

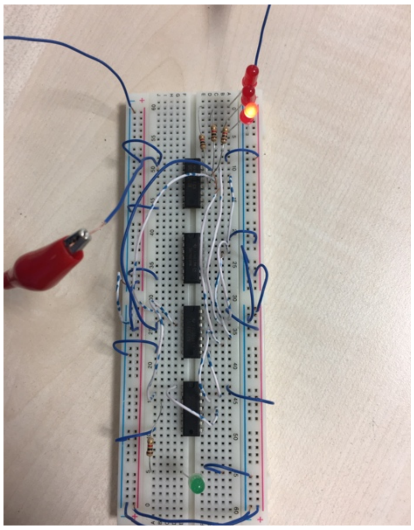

Figure 8: H:1 S:0 A:0 P:0

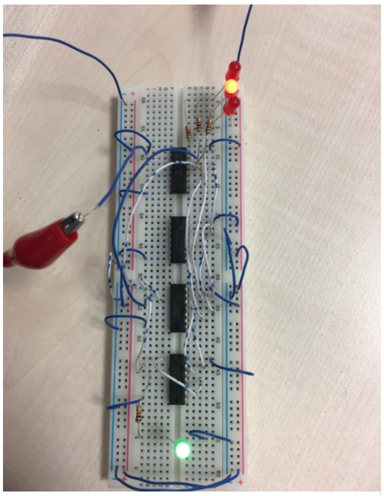

Figure 9: H:0 S:1 A:0 P:1

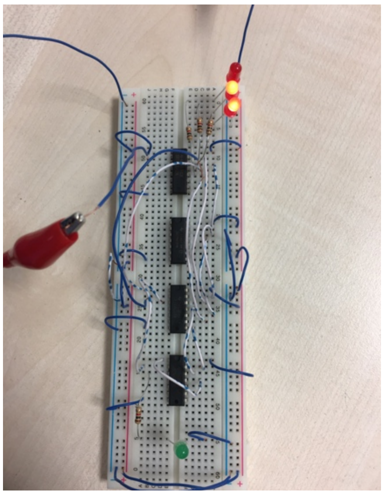

Figure 10: H:1 S:1 A:0 P:0

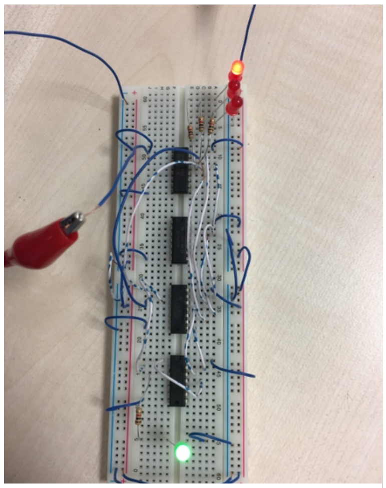

Figure 11: H:0 S:0 A:1 P:1

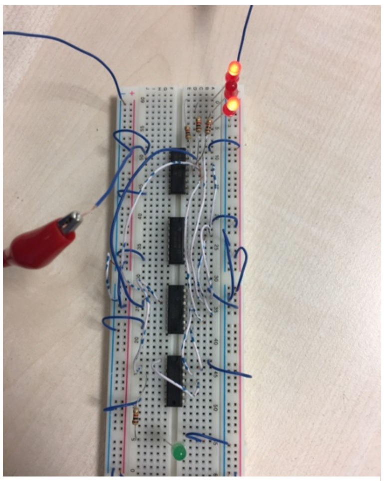

Figure 12: H:1 S:0 A:1 P:0

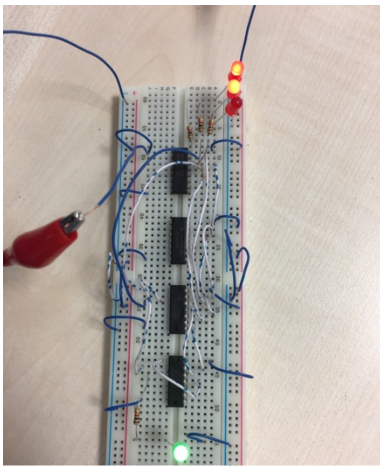

Figure 13: H:0 S:1 A:1 P:1

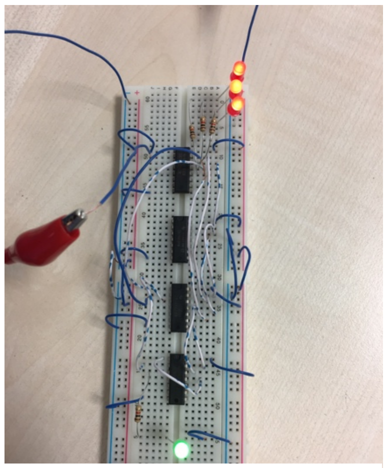

Figure 14: H:1 S:1 A:1 P:1

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- Conclusion

  This lab familiarized me with the breadboard and various circuit components. Thanks to this experiment, I now know how to use IC's and how to create an actual combinational circuit on a hardware level. It also gave me a small but important skill which is cutting wires easily. This experiment also gave us a closer look on logic circuits and definitely taught us more about the topic. Now it is much easier for us to imagine a scenario which represents a combinational circuit and bring it to life, either with a breadboard and circuit elements or a Basys 3.