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EE102-1 Lab 3 Report

# LAB 3: COMBINATIONAL LOGIC CIRCUIT

## • Purpose

The purpose of this lab is to learn building combinational logic circuit on a bredboard using a design of different logic gates. Additionally, counter will be used to test all possible inputs and oscilloscope and LEDS will troubleshoot if the circuit is working by showing its output.

## • Design Specifications

On this experiment, we used bredboard to build circuit on, instead of BASYS3 board. The three different inputs A,B,C are generated via 74HC163 counter, from 0 between 1, eight different combinations. Outputs are represented with LEDS, and light illustrate output is 1. I used 1 red led to show output of circuit. In addition to that, I also used 3 green leds to represent 3 different inputs A,B and C. I also used a Quad triple 3 input AND gate OCT (74LS/HC 11).

## • Methodology

On this lab, we will use a 4 bit counter to produce four waveforms. According to the function table from the datasheet, MR, CEP, CT, and PE should be high(5V), the operating modes.

I changed the circuit design from my previous lab because I wanted to learn more about working principle of AND gate, instead of OR gates. Additionally, The number of logic gates that is required is less compared to my previous design. From this reason, this design is easier to implement on a breadboard. On this lab, the output function Q will be like:

$$Q = \overline{A.B.C}$$

| A(Q0) | B(Q1) | C(Q2) | Q |
|---|---|---|---|
| 0 | 0 | 0 | 0 |
| 1 | 0 | 0 | 0 |
| 0 | 1 | 0 | 0 |
| 1 | 1 | 0 | 0 |
| 0 | 0 | 1 | 0 |
| 1 | 0 | 1 | 0 |
| 0 | 1 | 1 | 0 |
| 1 | 1 | 1 | 1 |

Table-1: Truth Table

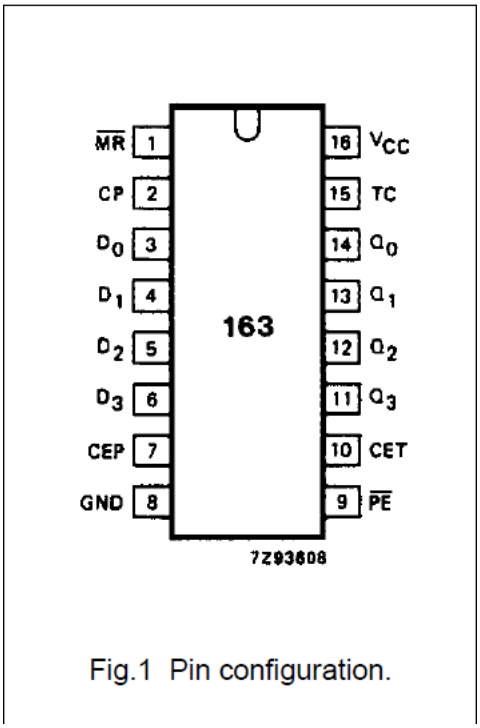



Figure-1: Pin Configuration of 74HC/HCT163

I used a signal generator and connected its positive knob to CP of 74HC/HCT163, and negative knob to ground. I also used a DC power supply, and connected it to positive and negative sides of my bredboard. Additionally, I connected Vcc(16) to positive, GND(8) to negative. I connected Q0, Q1 and Q2 with 1K ohm resistors and green leds to represent outputs of 74HC/HCT163, also inputs of AND gate. Additionally, after connecting the terminals of those leds to AND gate, I also used figure-2 on last part, connected negative sides of outputs from 74HC/HCT163 to (1),(2) and (13), and output for (12). I used 1K ohm resistor again and added a final red LED to represent output of the circuit. (Its longer side to positive-connected to resistor, shorter side to ground). Finally, after providing DC 5V from power supply and 1Vpp 1kHz signals from signal generator, I observed the results below.

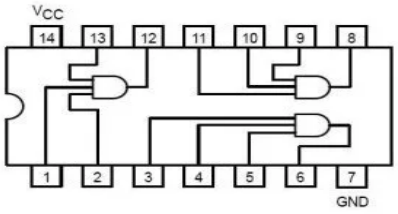



Figure-2: Quad Triple input AND gate 74LS/HC 11

# Results

First, 10Hz clock input photos of counter displayed on the oscilloscope screen is below.

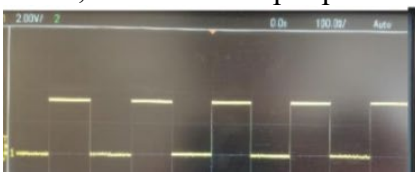


Figure 3.1: Output Q0

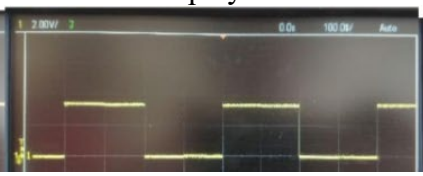


Figure 3.2: Output Q1

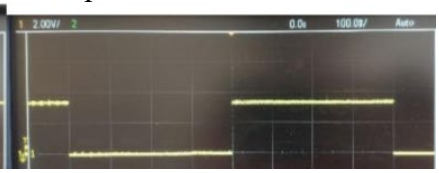


Figure 3.3:Output Q2

The counter behaves as expected, as each output waveform being twice the length of one on the left.

My results matched with expected from table-1 and the experiment was consistent. From figure 1, I can observe 1 output, and other figures illustrate different conditions when output is 0. When all leds are green, (111 input), the red output led also lights on. However, when only one of green input leds are turned of, the output becomes zero.

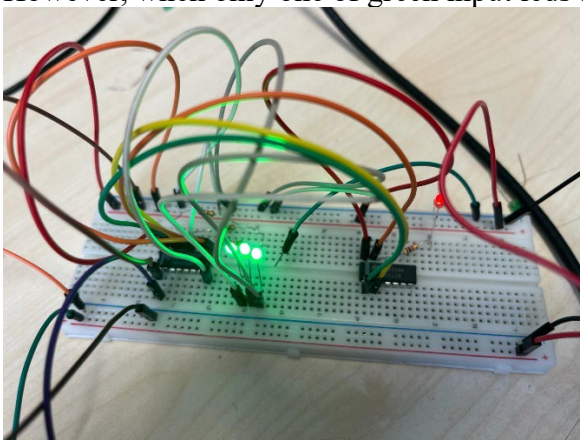


Figure-4: inputs are 1-1-1 and output is 1

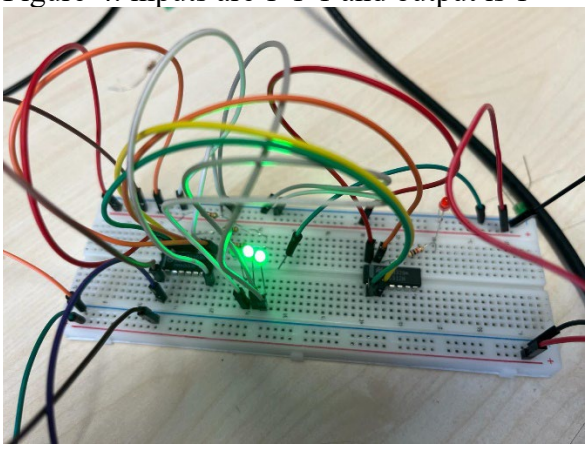


Figure-5: inputs are 0-1-1 and output is 0

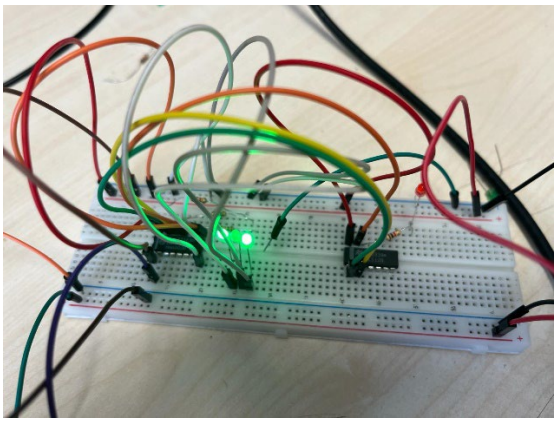


Figure-6: inputs are 1-0-1 and output is 0

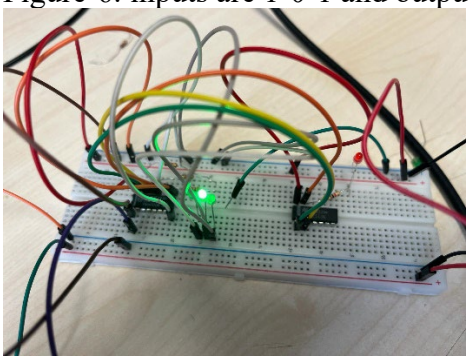


Figure-7: inputs are 0-1-0 and output is 0

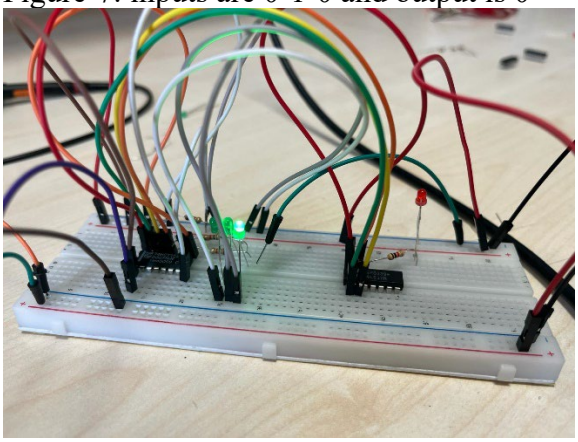


Figure-8: inputs are 0-0-1 and output is 0

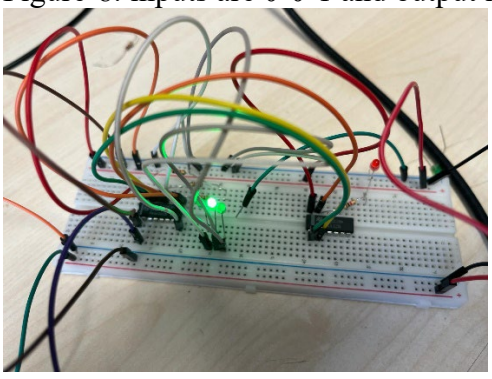


Figure-9: inputs are 0-1-0 and output is 0

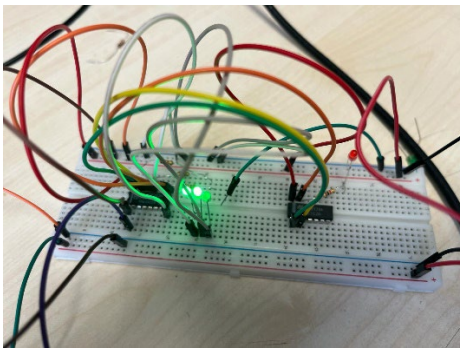


Figure-10: inputs are 1-1-0 and output is 0

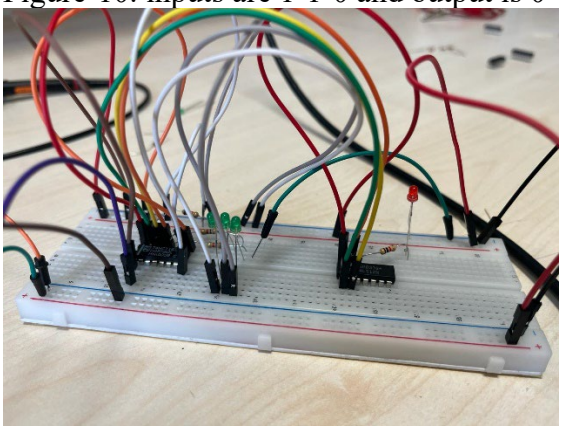


Figure-11: inputs are 0-0-0 and output is 0

Additionally, after completing the circuit design and implementation, I connected my circuit to an oscilloscope via prob(its positive knob to output led negative knob, and its negative knob to ground). I changed frequency to 1kHz and, I observed square waves with 1/8 peak frequency ratio with 8ms period. (00000001) Figure-7 and figure-8 clearly shows peaks of the wave, meaning as output changes, and becomes 1 when 1/8 of the conditions happen(1-1-1 input). This waves fit into attributes of 74HC/HCT163. However, due to physical conditions and bredboard components, my waves weren't perfectly squared.

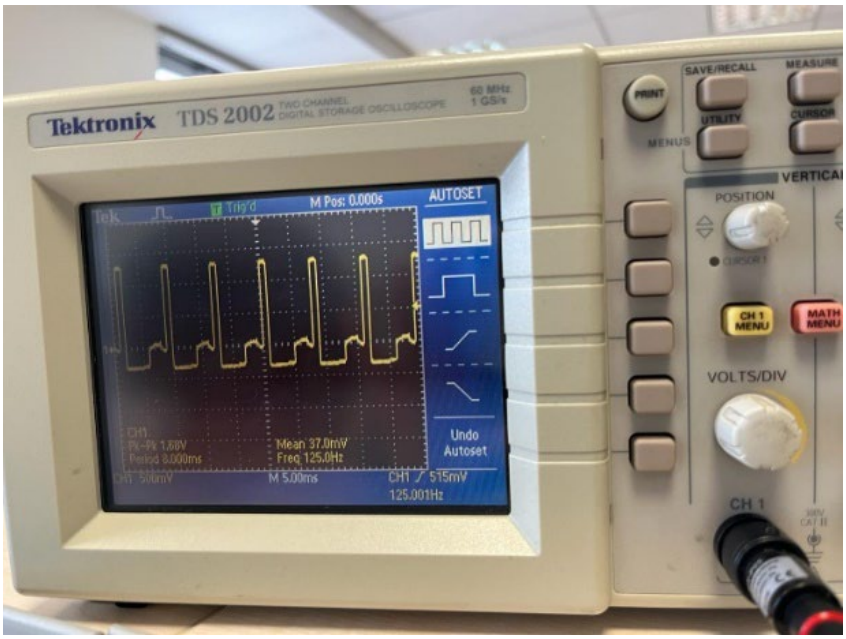


Figure-12: oscilloscope square waves

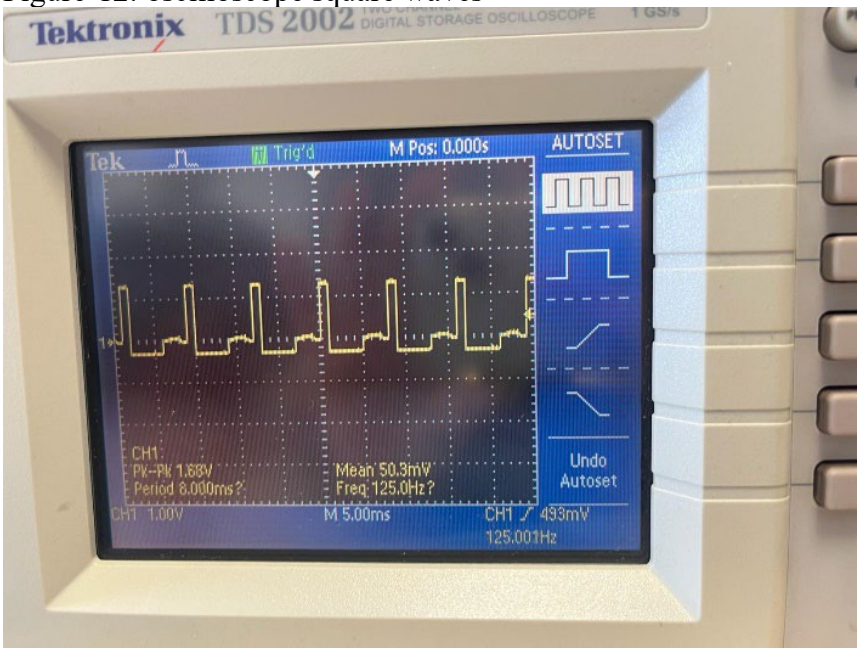
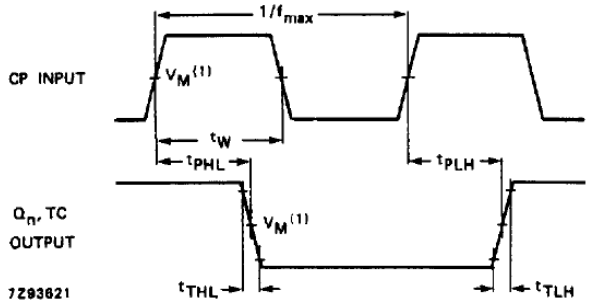


Figure-13: wave period: 8ms




(1) HC : $V_M$ = 50%; $V_I$ = GND to $V_{CC}$.
HCT: $V_M$ = 1.3 V; $V_I$ = GND to 3 V.

Fig.8 Waveforms showing the clock (CP) to outputs ($Q_n$, TC) propagation delays, the clock pulse width, the output transition times and the maximum clock frequency.

Figure-14: expected waveform schematic

# Conclusion

In conclusion, on this lab, I gained experience on building combinational logic circuit using bredboard, and testing it using different tools such as oscilloscope, signal generator,counter and LEDS, I also experimented with different clock frequencies to ensure circuit's functionality. The experiment was succesfull as my results matched with truth table.

# References

NXP Semiconductors. (2019). 74HC_HCT163 datasheet [Data sheet]. DigChip.com. Retrieved from https://www.digchip.com/datasheets/parts/datasheet/364/74HC_HCT163.php.

Lab Materials: (logic.gates.pdf, ledcircuit.jpg,74HC163signals.jpg)