Report: Combinational Logic Circuit

Bilkent University Electrical and Electronics Department
EE102-01 Lab 3

Semih Akkoç - 22103132

October 23, 2022

Purpose:

The intent of this lab was to study the essentials of the design and implementation of a combinational circuit on a breadboard using common logic gates. Additionally, to get acquainted with a 4-bit counter (74HC163) and LEDs, these components took place in the circuit.

Methodology:

This lab work primarily practiced on a real-life problem solved via a combinational circuit on a breadboard using common logic gates and a 4-bit counter. The problem was chosen as a half adder and it has been completed using a 2-input XOR gate and 2-input AND gate. Furthermore, for input signals 4-bit counter has been implemented rather than using switches this allowed a steady input signal and additionally benefited from LEDs to see the output results of the circuit.

Design Specifications:

As stated earlier, the problem was chosen to implement a half adder and in order to achieve this ambition, two inputs and two outputs have been constructed. For convenience, variable names have been assigned as follows:

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X: X input
Y: Y input
S: Sum of X input and Y input
C: Carry b
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Subsequently, forming a truth table revealed how functions need to be constructed by examining the truth table in Table 1. Consecutive functions can be understood with ease.

X	Y	S	C
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

Table 1: Truth Table

Two slightly different approaches can be taken from here. Such as, one can use canonical POS (product of sums) or can benefit from canonical SOP (sum of products). Although the two approaches are valid, after simplification, they would yield the same result. The less cumbersome and tedious way will be using canonical SOP. Therefore after applying canonical SOP. Functions can be found as follows:

$$S : X\bar{Y} + \bar{X}Y \equiv X \oplus Y \tag{1}$$

$$C : XY \tag{2}$$

This simple combinational circuit can be implemented by using a 2-input XOR gate (74LS86) to complete S and a 2-input AND gate (74LS08) to complete function C.

Results:

The suggested combinational circuit has been designed on the breadboard using common logic gates and a 4-bit counter. According to the 74HC163 datasheet, the counter has been set to the "clock" operating mode, and the consecutive inputs are then set to 5V (HIGH): MR, CEP, CET, PE. The inputs Q_n were assigned as X and Y inputs. After that XOR gates and AND gates were inserted into the breadboard and then connected according to the S and C functions. The circuit can be observed in the following figure.

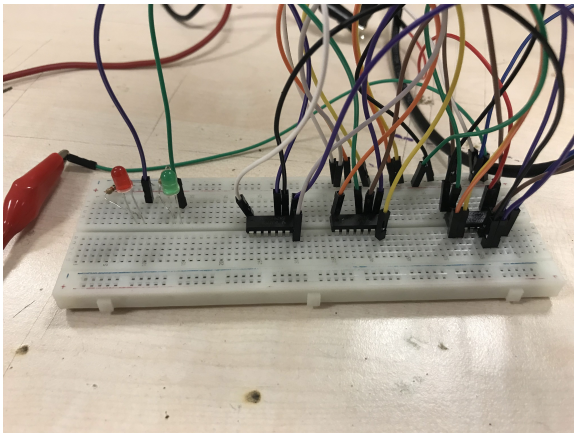


Figure 1: Circuit on breadboard.

In furtherance waveforms of the outputs are shown in the oscillator screen as follows blue waveform is S functions output and yellow waveform is C function as can be seen in Figure 2. As expected from the output signals waveform shows 0V for both functions S and C in the 00 state, and 5V for S in the 01 and 10 states and for C in the 11 state.

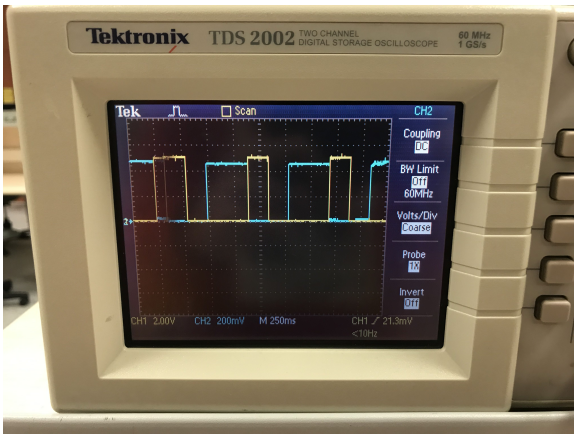
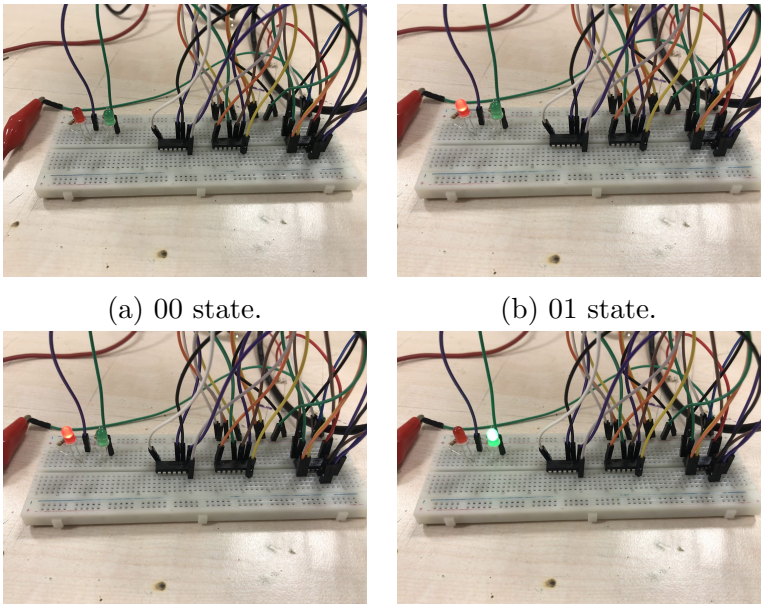


Figure 2: Waveforms on oscillator.

In favor of assigning inputs to 4-bit counters Q_n and outputs to LED indicators. The constraint file has been written. Finally, the whole design and its results can be checked in the following Figure 3.



(a) 00 state. (b) 01 state.

(c) 10 state. (d) 11 state.

Figure 3: Design on breadboard.

Conclusion:

The ambition of this lab was to get acquainted with the fundamentals of the design and implementation of a combinational circuit on a breadboard using common logic gates and a 4-bit counter. The outcomes of the lab were consistent with the anticipated results.

References:

- https://www.circuits-diy.com/74ls86-quad-2-input-exclusive-or-xor-gate-ic-datasheet/
- https://www.circuits-diy.com/74ls08-quadruple-two-input-and-gate-datasheet/
- https://github.com/CankutBoraTuncer/Bilkent-EEE102-Labs