ELE313 TERM PROJECT

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

In this project, our aim is to design Schmitt Transistor-transistor logic (TTL) NAND gate. This device is a kind of logic gate widely used in digital electronics. However, the circuit designed in the project is larger than the ones produced in the industry because the components in the circuit is larger in order to observe the behavior of the gate. We are utilizing from the configuration provided in the lecture notes of Electronics II and using same model of transistors (BJT and diodes) in order to provide consistence and ease in the calculations. The stages given in the project guideline are followed and the number of inputs are taken as 2. In the project, first we realized the concept of the circuit by understanding the behavior of the gate. Then, the theoretical calculations helped us to carry on the simulation and the design. We made some important assumptions such as current gain, turn-on voltage, etc. because we had to get specific numerical values to notice the the mode of operation of the transistors. Thirdly, we verified our calculations in the simulation part by getting graphs and measurements on the prototype design. The necessary adjustments are done on the simulation and the mistakes are corrected so that the fabrication of the gate should be appropriate. Finally, the fabrication part is shown by the photographs. We should note that one examining this project should have relevant information about the working mechanism of the TTL.

INTRODUCTION

The purpose of the project is to design a NAND gate working with the transistors. The need of the project ranges widely in the applications of the digital electronics. The circuit configuration is a basic Schmitt TTL NAND gate which is frequently used many applications such as computational devices or integrated circuits. The circuit operates in the modes of the BJT depending on the input signal. These modes are Saturation, Active, Cut-off and Reverse Active. The components of the circuit are standard and available in the industry and they are resistors, transistors, diodes, boards, power supply, inputs and cables. The resistor is power absorbing and current controlling device which is found in certain values in the industry. The Bipolar Junction Transistor is a current controlled device with 3 terminals. The diode is a one-way current passing device which is formed by PN junction. The boards are used to fabricate a circuit on it. The power supply provides electricity to circuit in order to operate. The inputs are digital signals at which high voltage is considered as 1 and low voltage is considered as 0. The cable makes the necessary connection between the nodes. The LTspice environment is used for testing the behavior of circuit and analyze the outcomes graphically. The approximate analysis techniques are used for theoretical calculations in which the default values of components such as turn-on voltage are assumed. The importance of the circuit comes from the providing switching operation between the logic gates. The circuit figure is well-known and available in many resources and it consists of 4 stages: input, Schmitt trigger, level shifter and totem pole output-splitter. It is acting as a NAND gate, inverse of AND gate. We have used AVO-meter and simulation programme to determine the output and behavior of the circuit. Note that the values of the resistances in the fabrication and theoretical calculations are slightly varried because of the availability in the industry. In addition, although the project is implemented by the transistors, the CMOS would be better choice because of the performance in terms of propagation delay and power dissipation namely power-delay product.

THEORETICAL CALCULATIONS

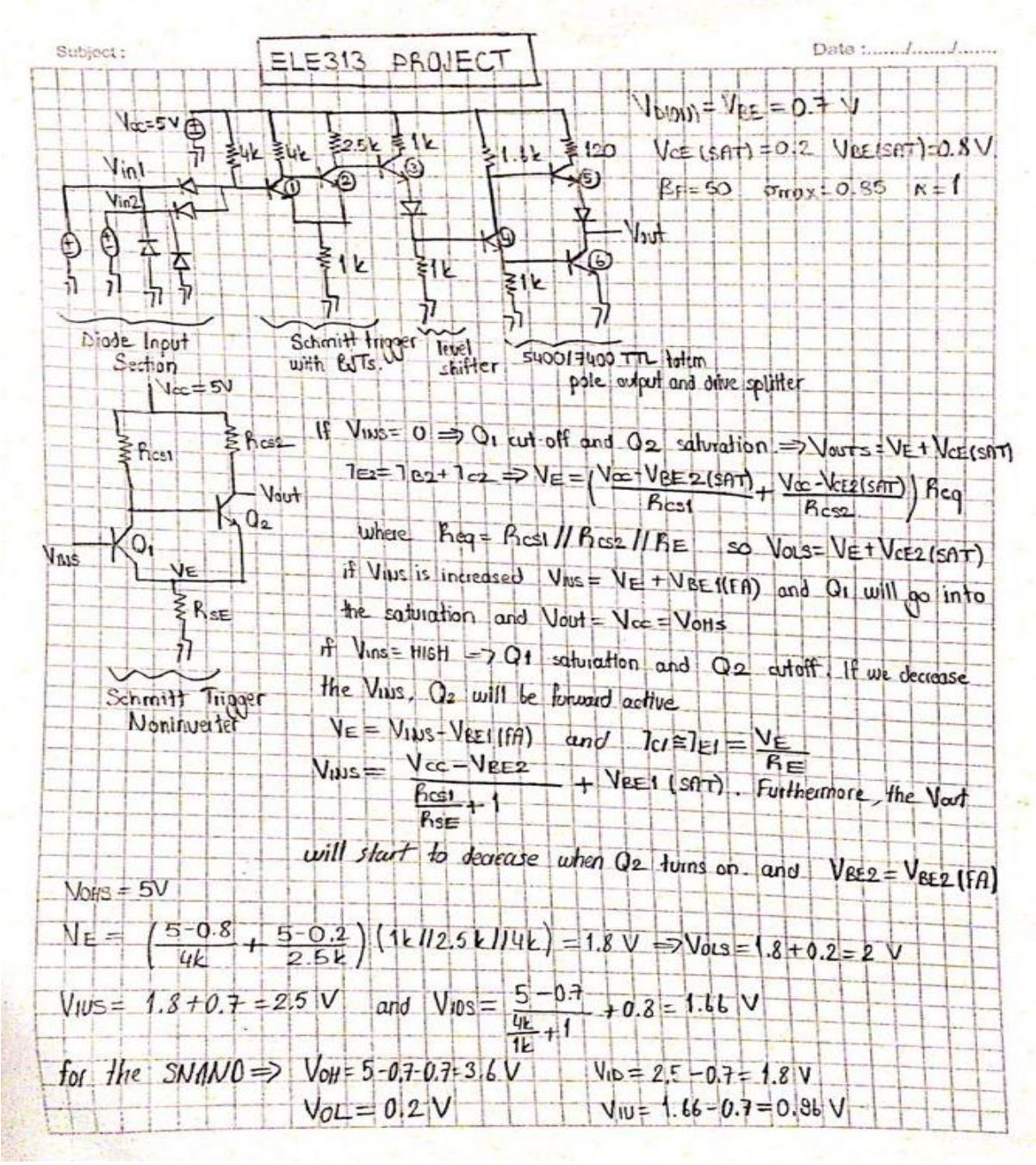

Fig. 1 - Theoretical Calculations Part 1

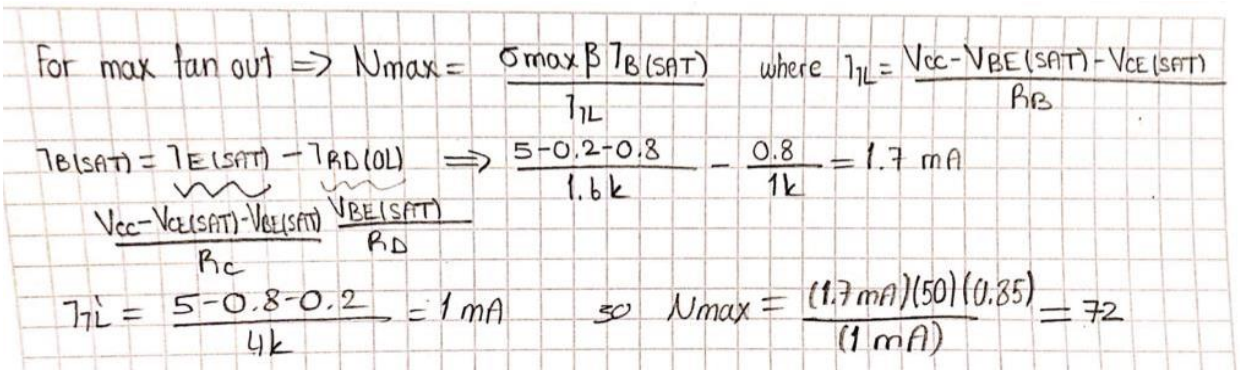

Fig. 2 - Theoretical Calculations Part 2

Input		Output
A	B	$Y=\overline{A.B}$
0	0	1
0	1	1
1	0	1
1	1	0

Table 1 - Truth table for NAND

CIRCUIT DESIGN AND SIMULATON RESULTS

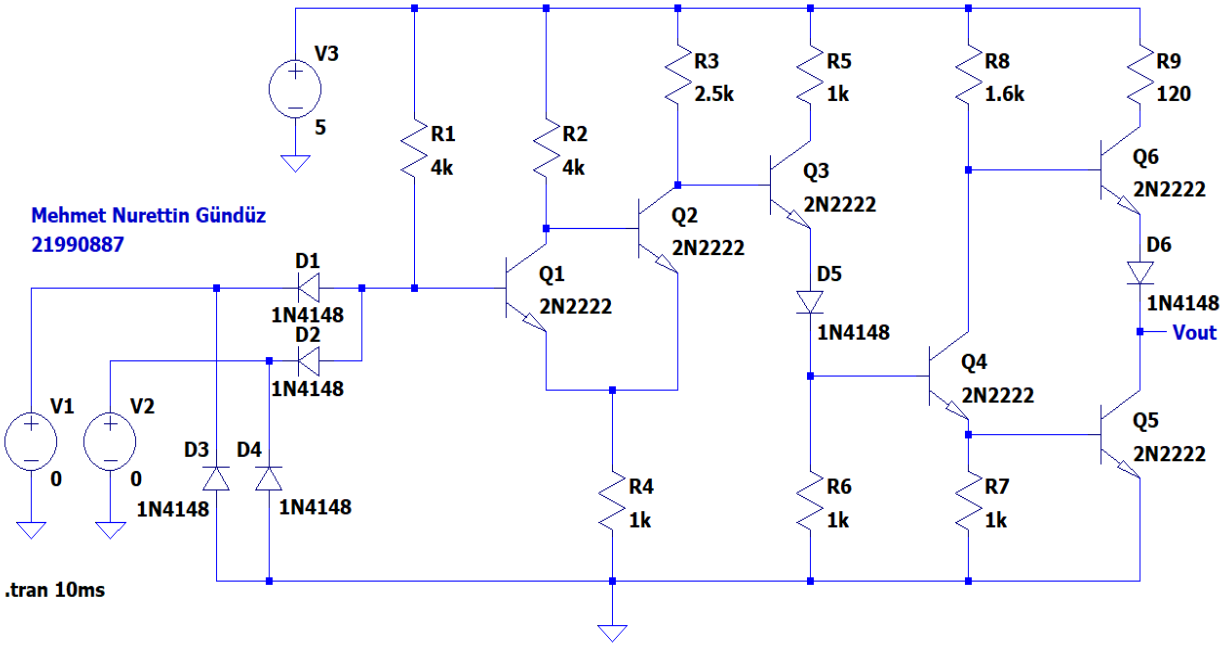

Fig. 3 - Circuit Schematic for SNAND

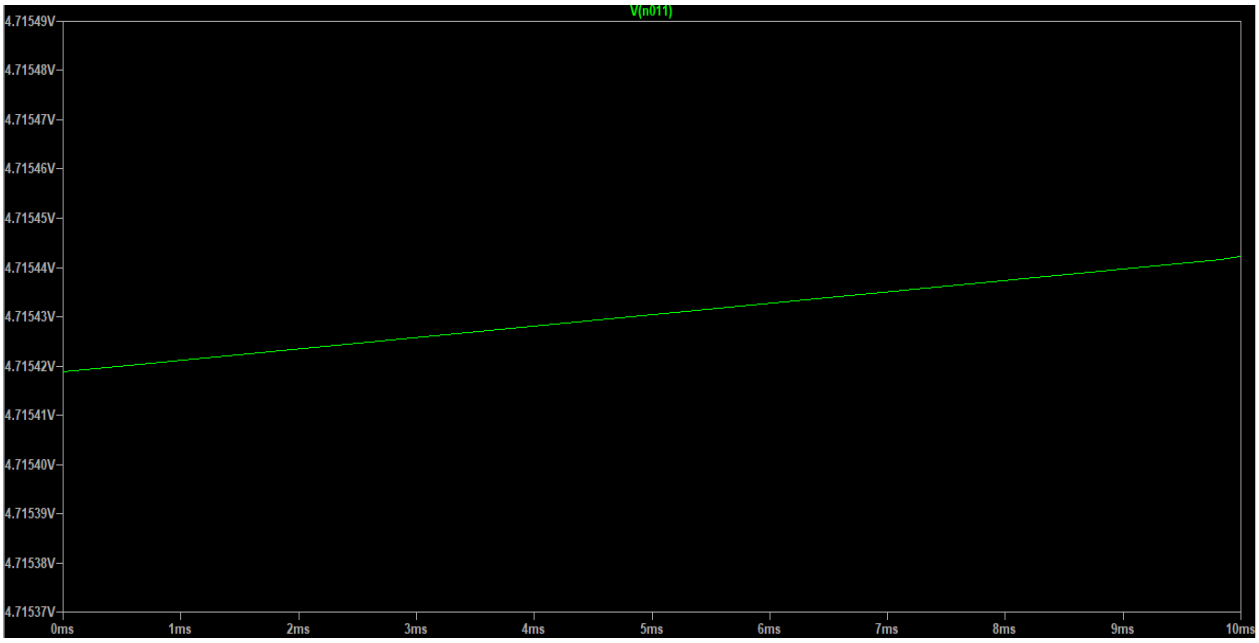

Fig. 4 - Vout when Vin1 = 0 and Vin2 = 0

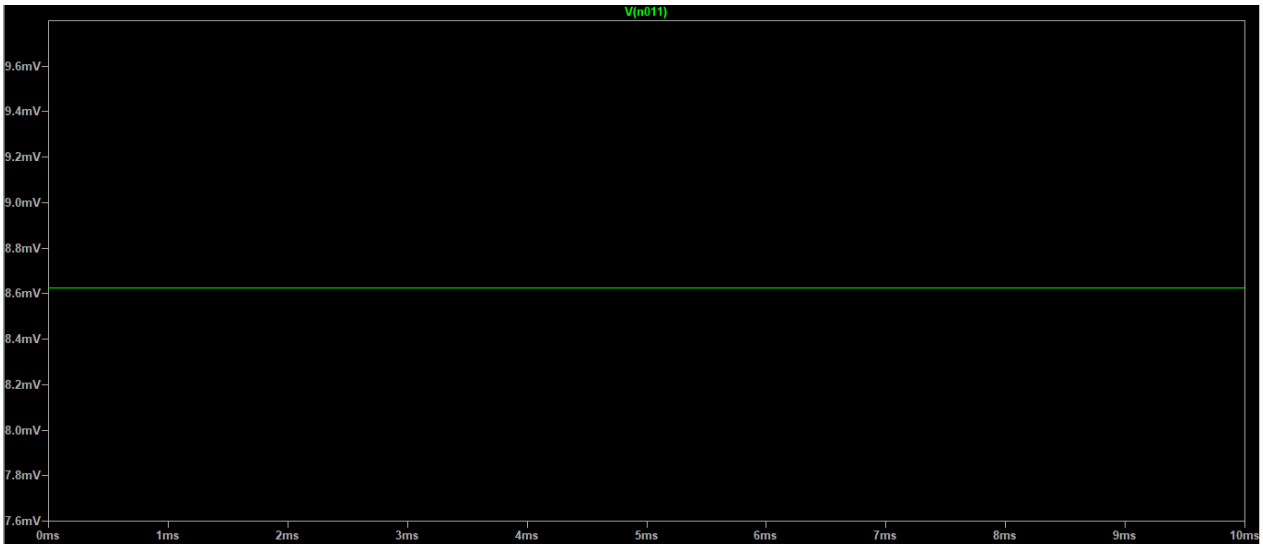

Fig. 5 - Vout when Vin1 = 5 and Vin2 = 5

Comment 1: The results are consistent with those found theoretically. Note that 5 refers to the case at which V is high and 0 refers to the case at which V is low. Therefore, Vout = 4.71 V is regarded as high and Vout = 8.6 mV is regarded as low.

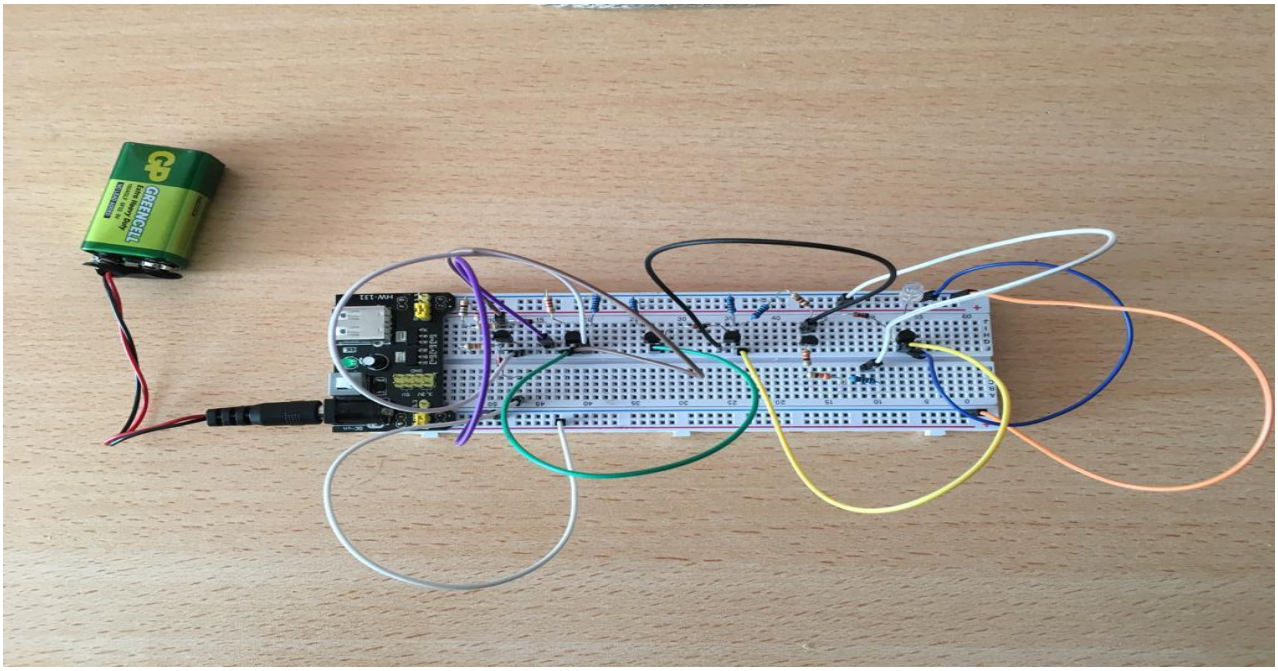

Fig. 6 - The top view of the circuit

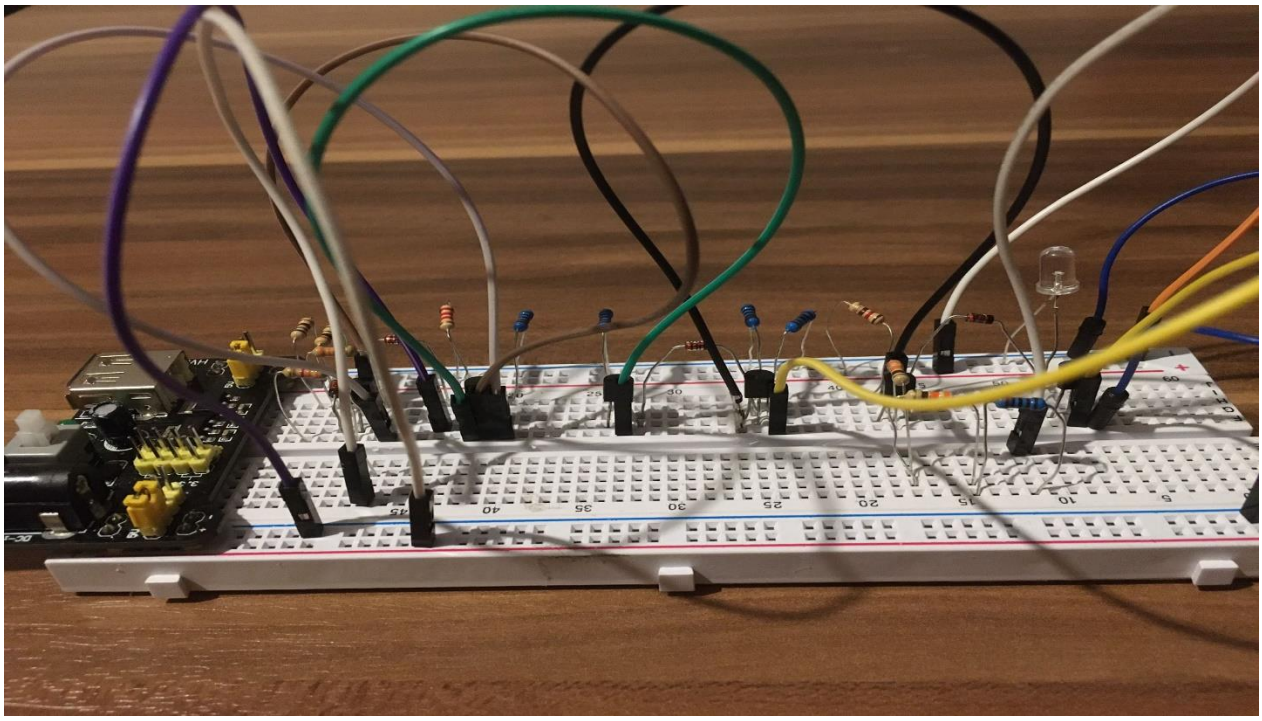

Fig. 7 - The back view of the circuit

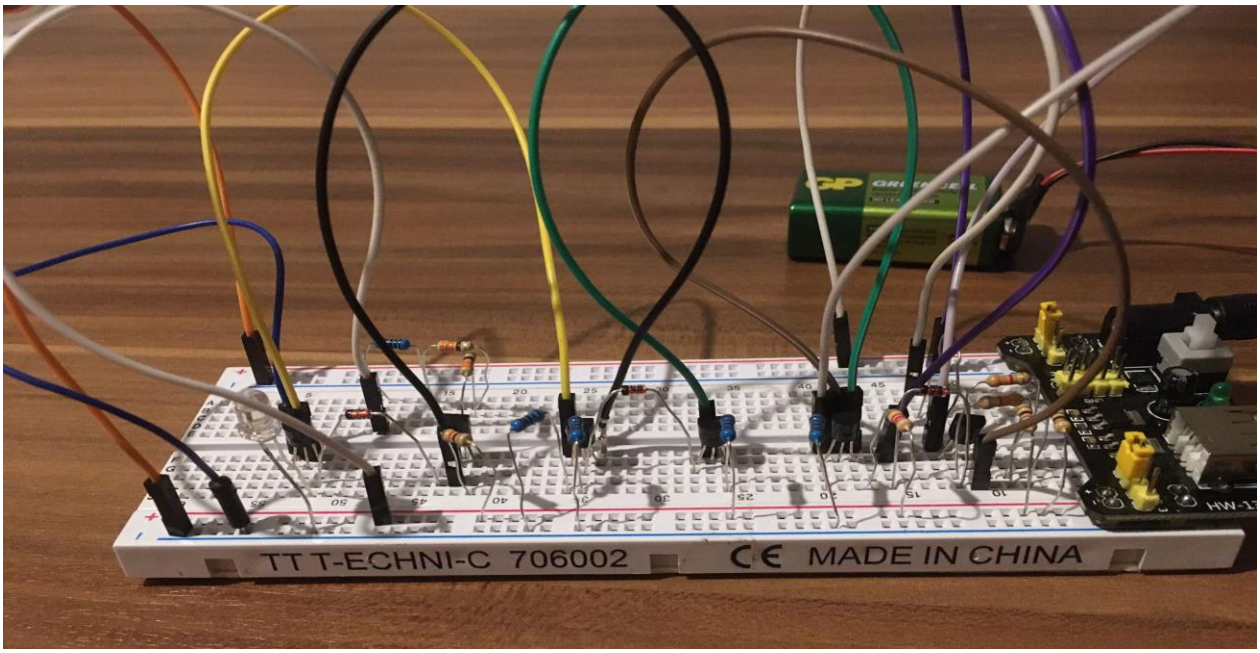

Fig. 8 - The front view of the circuit

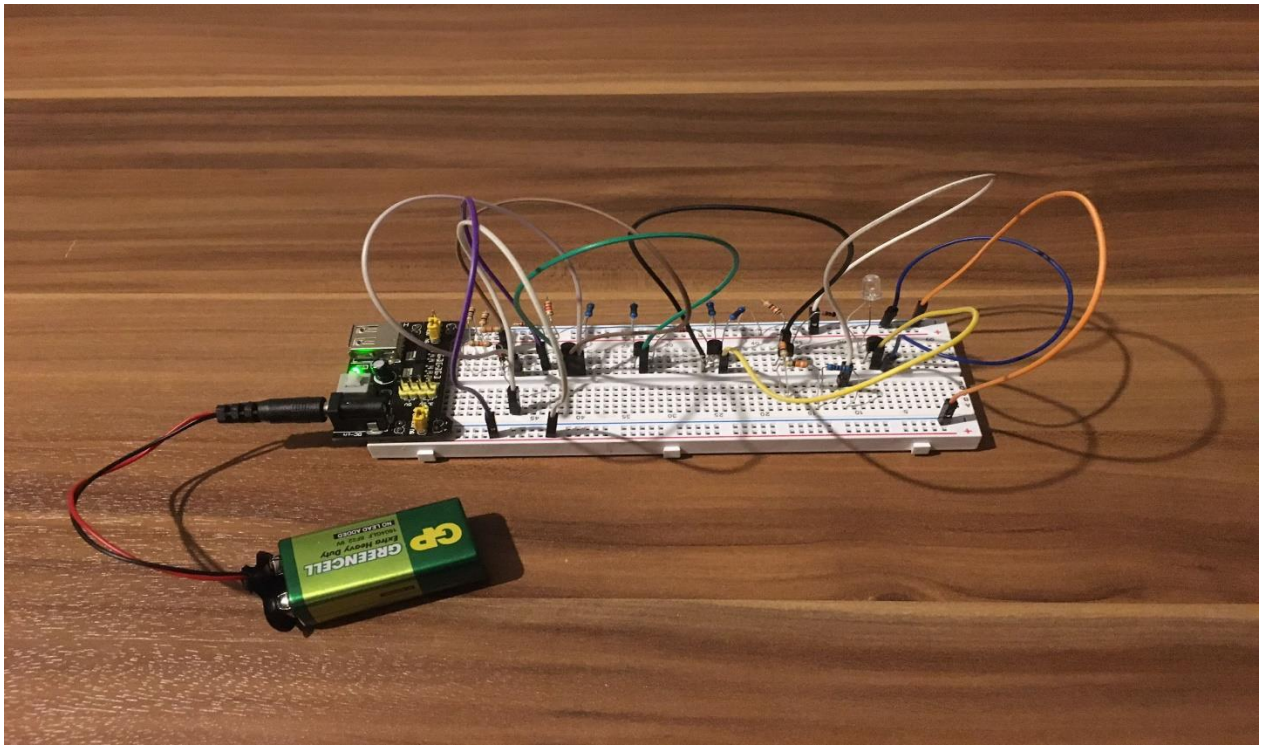

Fig. 9 - Vout when Vin1 = High and Vin2 = High

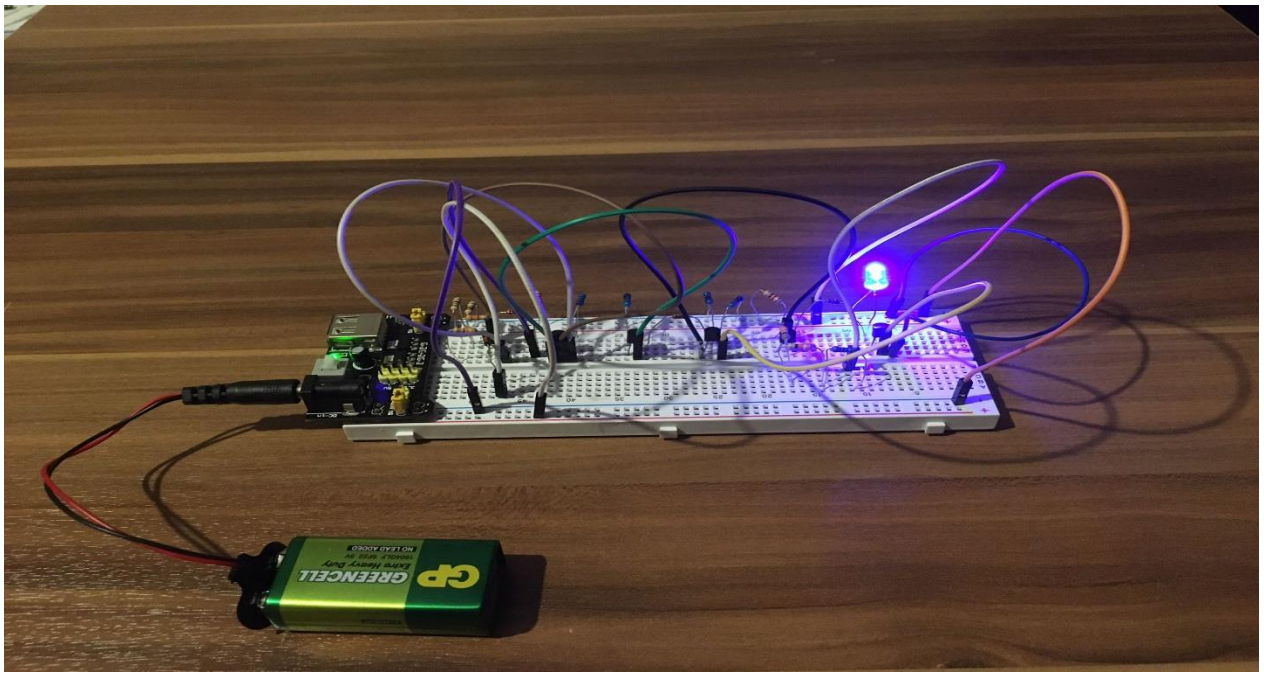

Fig. 10 - Vout when Vin1 = Low and Vin2 = High

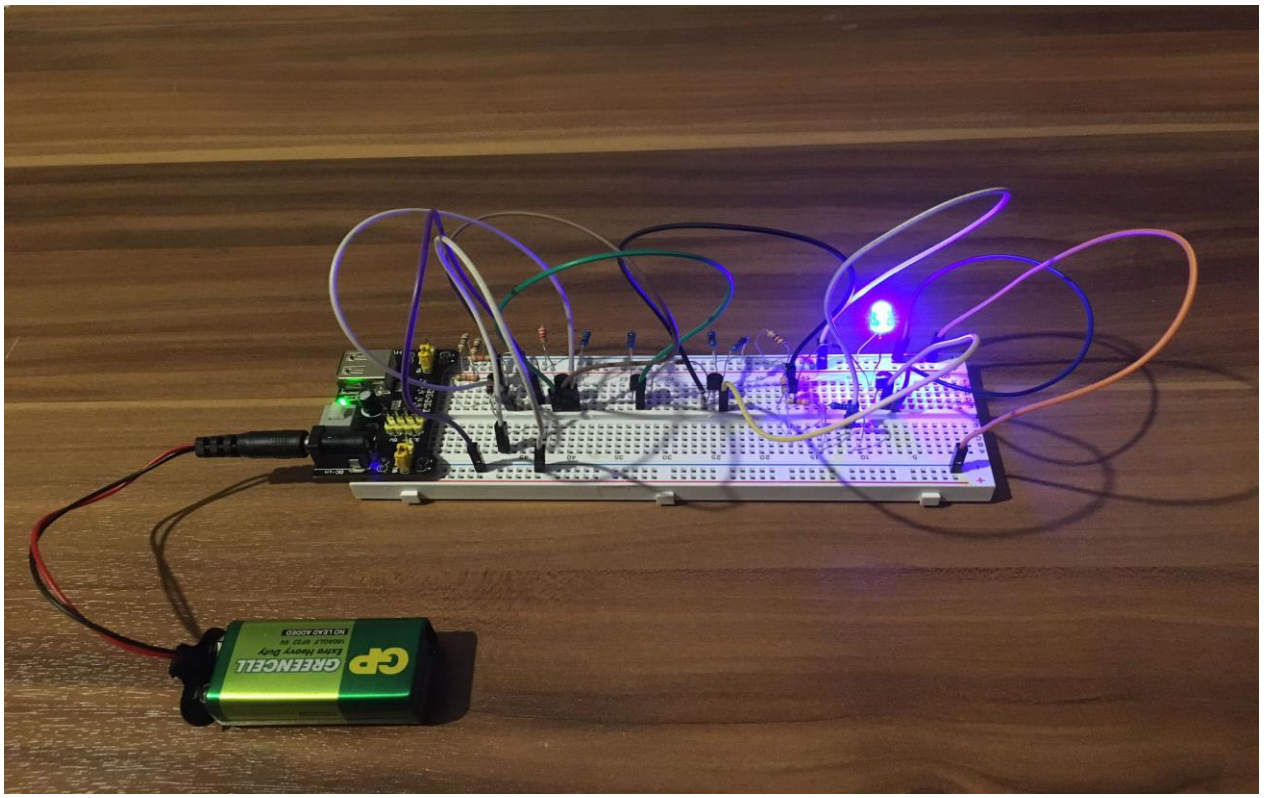

Fig. 11 - Vout when Vin1 = Low and Vin2 = Low

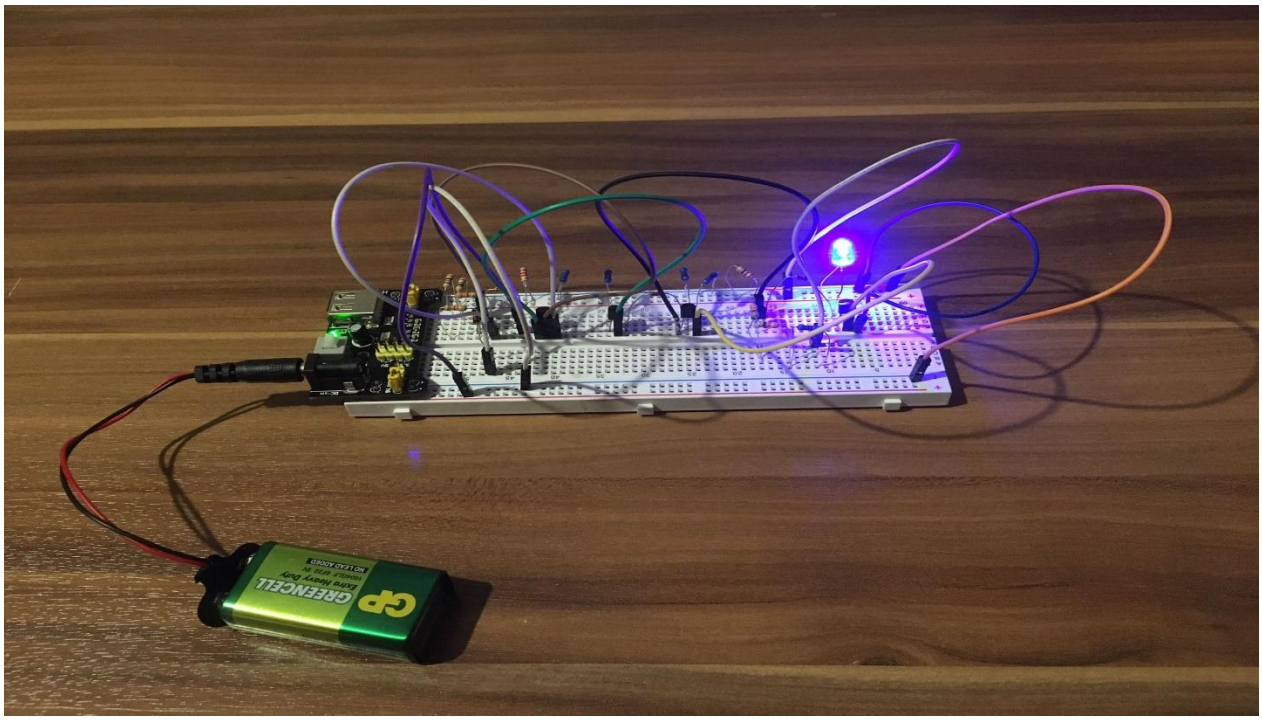

Fig. 12 - Vout when Vin1 = High and Vin2 = Low

Comment 2: The results are consistent with those found in the simulation. Note that HIGH refers to the case at which the led is on and LOW refers to the case at which the led is off. One looking to the figure should notice that the led, i.e. totem pole output stage is located at the right while the input stage is located at the left. Also, we can see the Schmitt trigger and level shifter stages from left to right, respectively.

CONCLUSION

We designed a Schmitt trigger TTL NAND gate in this project. It realizes two inputs and works as an inverse of AND gate. This device is widely used in digital electronics at smaller sizes. The circuit schematic used in the project is standard and easy to understand. In the project, the same type of transistors are used in order to show the calculations clearly. One looking to the project should know the modes of operation of transistor and logic behind the TTL. Firstly, we draw the circuit on the paper and pay attention to the requirements while picking up the resistances. Then, we simulate the circuit on the programme and verify the theoretical results. Finally, we fabricate the circuit on the breadboard and test the 4 cases in the truth table in order to see the whether the output is correct. The results of the project are consistent with those calculated and simulated theoretically. It is important to note that we used the resistance values which are available in the industry and made series connections if necessary. Naturally, the problems occurred during the fabrication but after several adjustments, we were able to come up with proper mechanism. The solutions can be listed as changing the board, decreasing-increasing the resistance and using different connections. We worked with 5 V for power supply and inputs and placed blue led to see the output. The project is simple and the behavior of the circuit isn't complicated. However, some unexpected problems may occur but they are resolvable. In my opinion, since the correct results

are obtained, the project can be considered as successful. On the other hand, the project lacks of stripboard design. If I had the project again, I would use the same configuration because it is basic and it doesn't need further modifications. Also, I would set up the circuit on a stripboard in a larger time.

PROJECT ASSESSMENT SURVEY

1. What are the throublesome points of the project process?
2. What was your method to solve your problems?
3. What are your gains from this Project?
4. Do you think the project process is successful? Vote: 1 is unsuccessful and 5 is perfect. Why?

1		2		3		4		5	

1. In my opinion, there are 3 troublesome points of the project: Narrowness, Time and Board. Since we deal with small components and work on narrow environment, making the connection between the nodes can be difficult for me. Also, observing repititive fails at the output and trying to solve the problem over and over take considerable time. However, I change the board two times and reconstruct the circuit in order to avoid the short circuit. In the end, I get the correct results.

2. Changing the components and the board are the main methods to solve problems. In addition, I try different connections by using extra jumpers. At the end of the numerous attempts, the methods worked and the truth table of the gate was tested successfully.

3. The project is beneficial in terms of understanding the TTL concept and gaining practice. Before the project, I couldn't understand the TTL modes of operation clearly. However, the behavior of the each component in the circuit stuck better in my mind after completing the project. Also, rebuilding the circuit again and again help me to increase my speed while working with similar circuits. Last but not least, it is pretty satisfying to get the correct output and see the led shining at the end.

4. My vote for the project is 4. It is clear that the efficiency of gate decreases on the breadboard compared to stripboard. On the other hand, the goal is to produce NAND gate working properly. Although I get the truth table of the gate correctly, I don't complete the project. Hence, I cannot give myself full points and consider as perfect.

LIST OF REFERENCES

1. LTspice XVII

2. Electronics 2 Lecture Notes

3. Datasheets of Transistors (OnSemi)

4. ElectronicsHub