Title: Verification of De Morgan's Theorem

Objectives

The objectives of this experiment are:

- To verify De Morgan's Theorem by constructing truth tables for both sides of the equations $\overline{A + B} = \overline{A} \cdot \overline{B}$ and $\overline{A \cdot B} = \bar{A} + \bar{B}$.
- To gain practical experience with integrated circuits (ICs) for implementing logic gates on a breadboard.
- To confirm the equivalence of the logical expressions using experimental results.

Introduction

De Morgan's Theorem is a fundamental principle in digital electronics that relates the complement of a logical expression to the complements of its individual variables. The theorem states two key equivalences: (1) the complement of an OR operation is equivalent to the AND of the complemented inputs ($\overline{A + B} = \overline{A} \cdot \overline{B}$), and (2) the complement of an AND operation is equivalent to the OR of the complemented inputs ($\overline{A \cdot B} = \bar{A} + \bar{B}$). This experiment aims to verify these equivalences by constructing circuits using the AT-700 Portable Analog/Digital Laboratory, with appropriate ICs (e.g., 7404 for NOT, 7408 for AND, 7432 for OR) to implement both sides of each equation. By testing all input combinations and observing outputs via an LED light, the experiment confirms the theoretical validity of De Morgan's Theorem.

Procedures

The experiment was conducted following the steps outlined in the lab manual, with some assumptions for clarity due to incomplete procedural details in the provided document:

1. **Identify Pin Configurations**: Determined the correct input and output pin numbers for the required ICs (assumed to be 7404 for NOT, 7408 for AND, and 7432 for OR, based on previous sessions) using their datasheets.
2. **Setup Circuit on Breadboard**: Installed the components for both sides of De Morgan's Theorem equations as per the circuit diagram (assumed to be Fig. 5-1 from the manual's

context) on the AT-700 breadboard. Connected pin 14 of each IC to +5V and pin 7 to GND on the AT-700 power supply.

3. **Connect Inputs and Outputs**: Connected data switches "2" and "3" to points A and B of the circuit for both equations. Connected the LED light to the output points of the circuits representing $\overline{A+B}$, $\overline{A}\cdot\overline{B}$, $\overline{A\cdot B}$ *and* $\bar{A}+\bar{B}$.

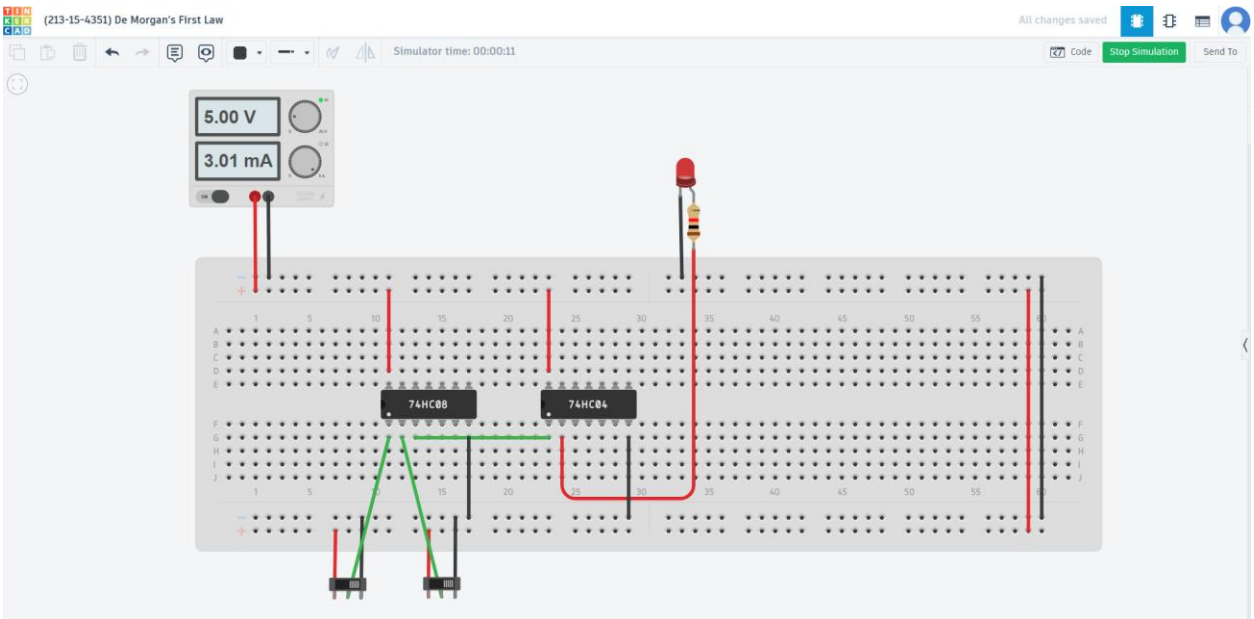
4. **Test Input Combinations**: Changed the data switches "2" and "3" between logic 0 and 1 positions to apply all possible input combinations (00, 01, 10, 11) for both equations. Observed the LED light, where a lit LED indicated logic 1 and a dark LED indicated logic 0.

5. **Record Results**: Recorded the observed outputs in truth tables to verify the equivalence of both sides of each De Morgan's Theorem equation.

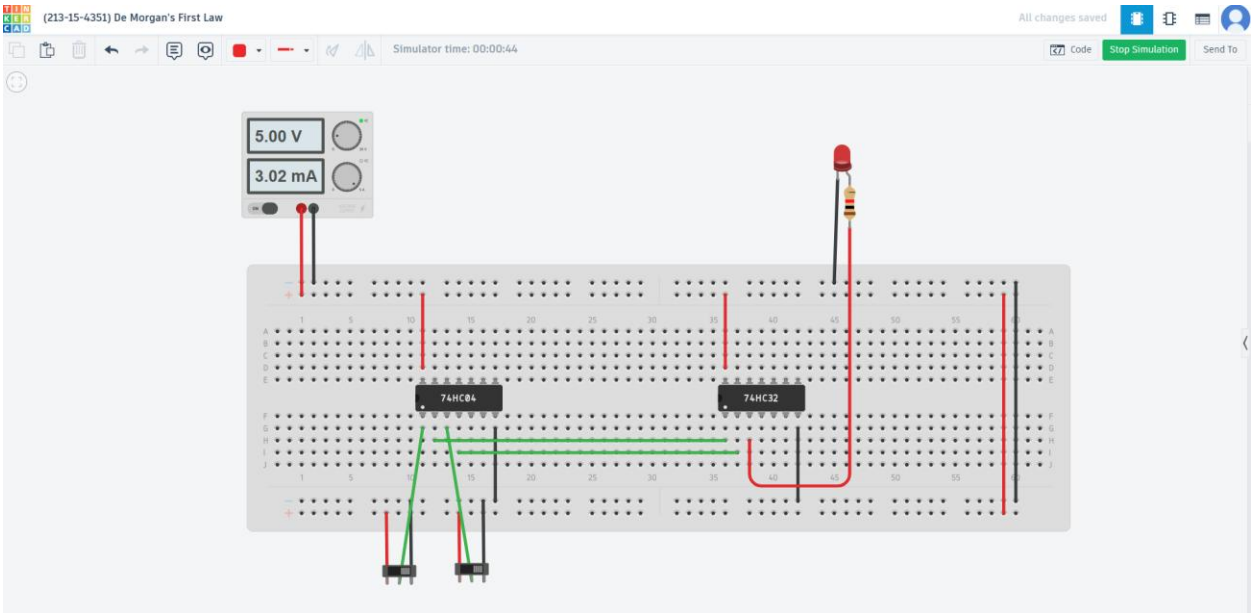
Experiment Pictures

De Morgan's First Law:

$$\overline{A+B}$$

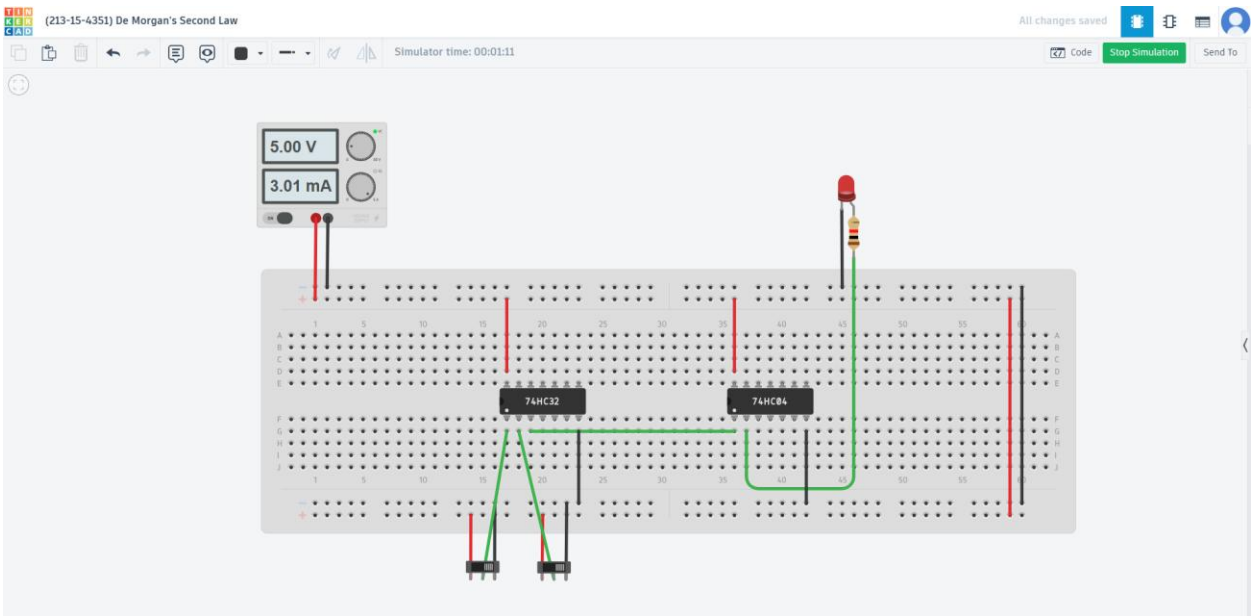


$$\overline{A} \cdot \overline{B}$$

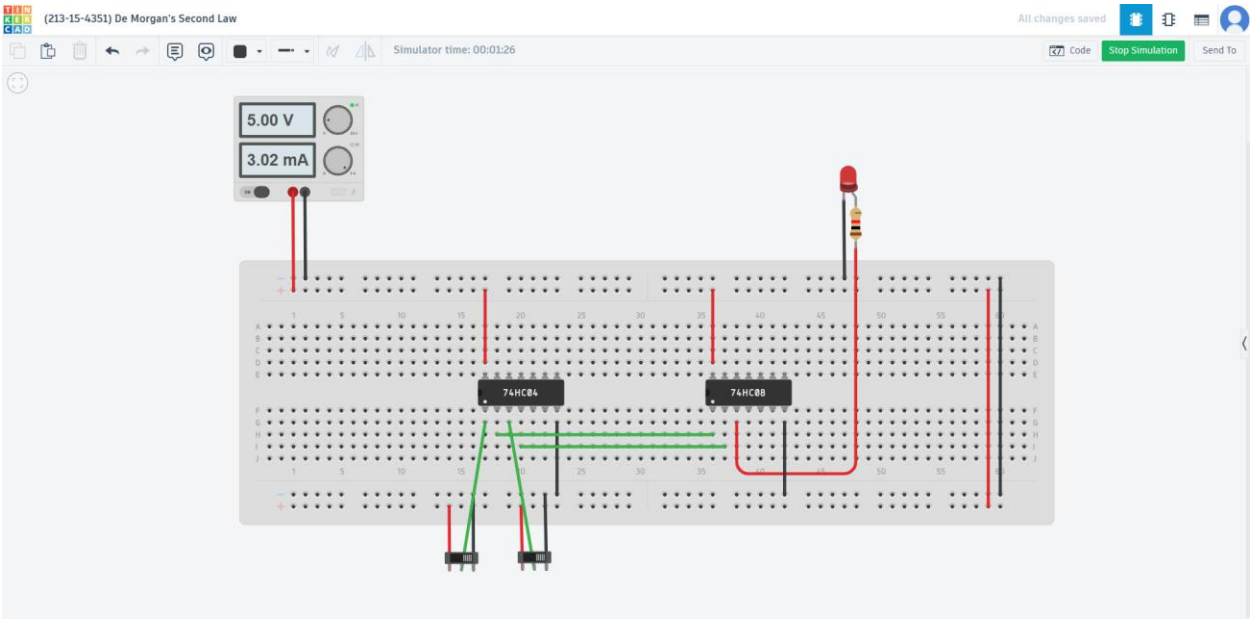


De Morgan's Second Law:

$$\overline{A \cdot B}$$



$$\bar{A} + \bar{B}$$



Tinkercad Link

De Morgan's First Law: https://www.tinkercad.com/things/e8gibhmrwkQ-213-15-4351-de-morgans-first-law-?sharecode=lGMoMjX9R2_Seyj-smgsN_4xzEKaSYPBY6VlsnACCl8

De Morgan's Second Law: https://www.tinkercad.com/things/3SgmH5ywcsh-213-15-4351-de-morgans-second-law?sharecode=nNoqYEyJ6XCdeHbeHlhOqXbxDFfnd6eOI0VJCpEAPoY

Experimental Results

The experiment tested all possible input combinations for both sides of the two De Morgan's Theorem equations. The results are summarized in the following truth tables, confirming the equivalence of the expressions:

Equation 1: $\overline{A + B} = \overline{A} \cdot \overline{B}$

A	**B**	**A + B**	$\overline{A + B}$	$\overline{A}$	$\overline{B}$	$\overline{A} \cdot \overline{B}$
0	0	0	1	1	1	1
0	1	1	0	1	0	0
1	0	1	0	0	1	0
1	1	1	0	0	0	0

Equation 2: $\overline{A \cdot B} = \bar{A} + \bar{B}$

A	**B**	**A·B**	$\overline{A \cdot B}$	$\bar{A}$	$\bar{B}$	$\bar{A} + \bar{B}$
0	0	0	1	1	1	1
0	1	0	1	1	0	1
1	0	0	1	0	1	1
1	1	1	0	0	0	0

The LED light showed a lit LED for logic 1 and a dark LED for logic 0, confirming that the outputs of $\overline{A + B}$ $matched$ $\overline{A} \cdot \overline{B}$, and the outputs of $\overline{A \cdot B}$ $matched$ $\bar{A} + \bar{B}$ for all input combinations.

Conclusion

This experiment successfully verified De Morgan's Theorem by constructing and testing circuits for both sides of the equations $\overline{A + B} = \overline{A} \cdot \overline{B}$ and $\overline{A \cdot B} = \bar{A} + \bar{B}$. The truth tables confirmed that the outputs of the left-hand and right-hand sides of each equation were equivalent for all input combinations, validating the theorem. The practical setup on the AT-700 breadboard, using assumed ICs (7404, 7408, 7432), provided valuable experience in circuit design, IC pin configurations, and digital circuit testing. This experiment deepened the understanding of logical equivalences and their practical implementation in digital electronics.