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Objectives

- To be able to experimentally verify the De-Morgan's theorem using two input variables.

Components Required

- 7432 quad 2-input OR gate
- 7404 hex inverter
- LED
- 7430 quad 2-input AND gate
- DIP switch
- Three 1 kΩ resistors

De-Morgan's Theorem

De-Morgan's Theorems are basically two sets of rules or laws developed from the Boolean expressions for AND, OR and NOT using two input variables, A and B. These two rules or theorems allow the input variables to be negated and converted from one form of a Boolean function into an opposite form.

De-Morgan's first theorem states that two (or more) variables NOR´ed together is the same as the two variables inverted (Complement) and AND´ed, while the second theorem states that two (or more) variables NAND´ed together is the same as the two terms inverted (Complement) and OR ´ed. That is replace all the OR operators with AND operators, or all the AND operators with an OR operator.

De-Morgan's First Theorem

- $(X + Y)' = X'. Y'$ .... (a)

De-Morgan's Second Theorem

- $(X. Y)' = X' + Y'$ .... (b)

Procedure

1. Build the circuit for left part of equation (a) as shown in figure 1 and monitor the behavior of LED for different test inputs
2. Then complete the circuit of figure 2 for the right part of equation (a) and complete the truth table 3.1 by testing each combination of inputs of appropriate switches
3. Compare both the column results and check whether equation (a) is verified or not
4. Repeat the above process by building the circuits of figure 3 and 4 and comparing its results for De-Morgan's theorem verification of equation (b)

Logic Circuit Diagram

- **Verifying De-Morgan's First Theorem**

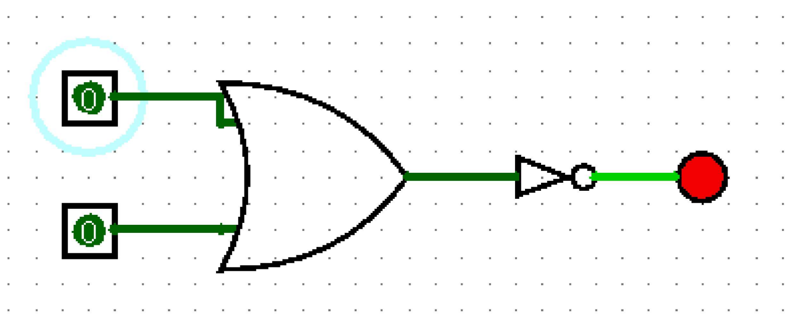


Fig. 1: Circuit for (X+Y)'

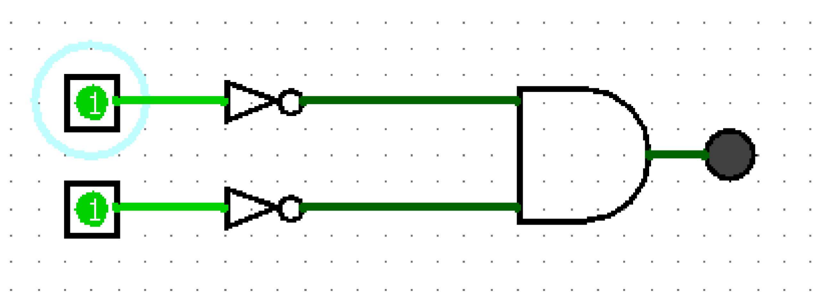


Fig. 2: Circuit for X' . Y'

Verifying De-Morgan's First Theorem using Truth Table

X	Y	(X + Y)'	(X' . Y')
0	0	1	1
0	1	0	0
1	0	0	0
1	1	0	0

Truth Table

➢ Verifying De-Morgan's Second Theorem

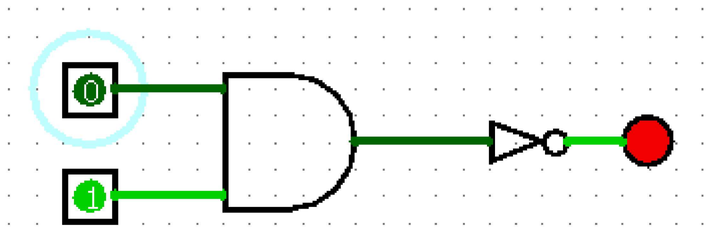


Fig. 3: Circuit for (X.Y)'

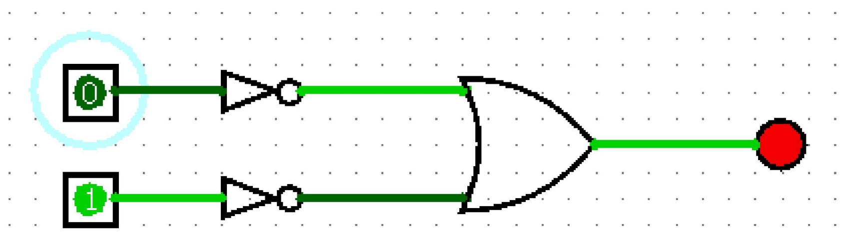


Fig. 4: Circuit for (X' + Y')

Verifying De-Morgan's Second Theorem using Truth Table

X	Y	(X . Y)'	(X' + Y')
0	0	1	1
0	1	1	1
1	0	1	1
1	1	0	0

Truth Table

Experiment Pictures:

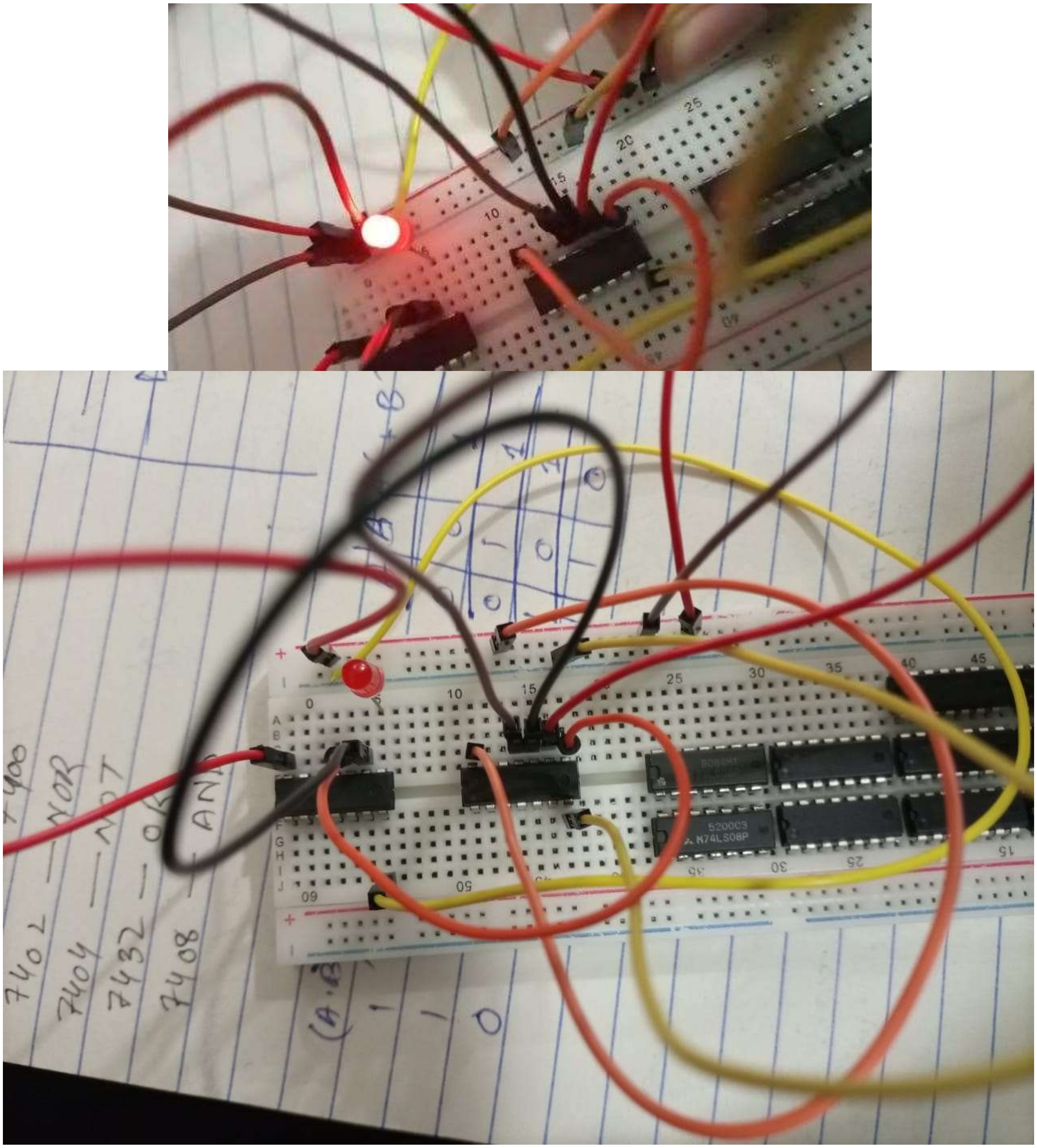


Figure :Experiment's Pictures

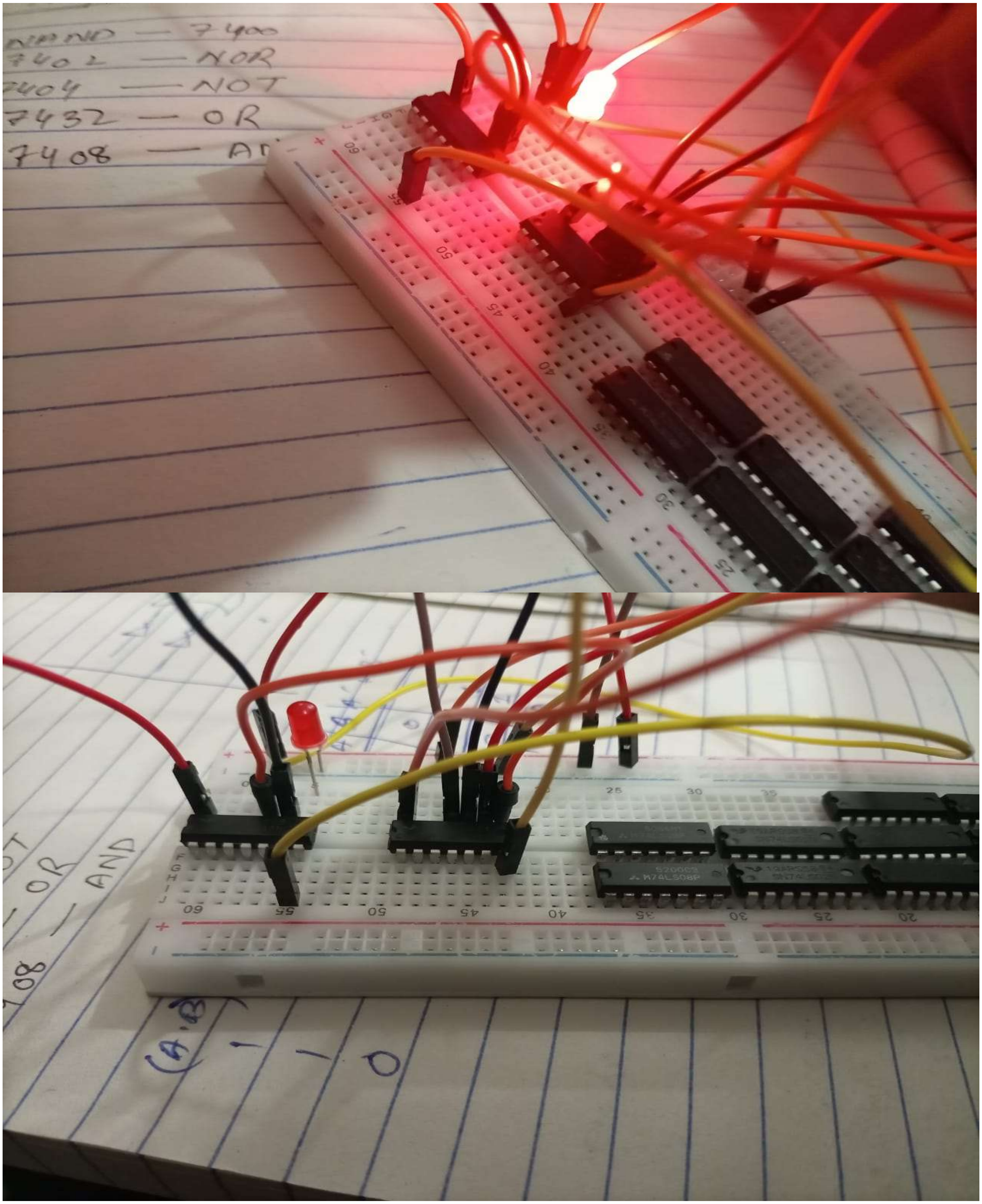


Figure: Experiment's Pictures

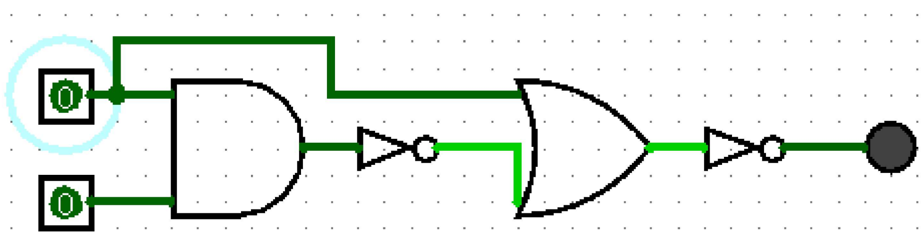
REVIEW QUESTIONS

Q1. Simplify the expression using De-Morgan's theorems and verify the two expressions experimentally.

$$F = ((A \cdot B)' + A)'$$

Answer:

From the Algebraic simplified expression and experimental circuit implementation, it is clear that the particular function F has zero output.



$F = ((A \cdot B)' + A)'$

Applying De-morgan's law.

$F = ((A \cdot B)')' \cdot A'$

$F = A \cdot B \cdot A'$

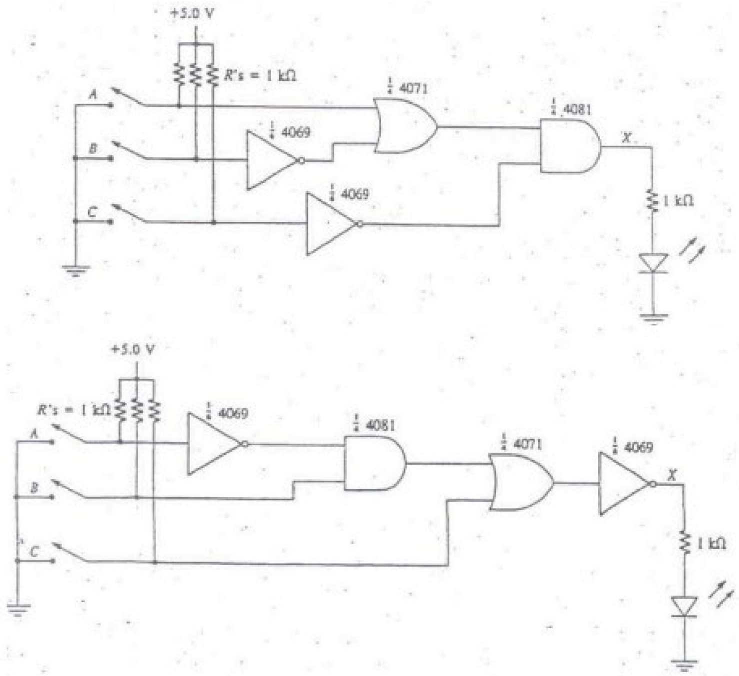
since $A \cdot A' = 0$

$F = B \cdot 0$

Also, $A \cdot 0 = 0$

$\boxed{F = 0}$

Q2. Determine experimentally whether the given circuits are equivalent. Then use De-Morgan's theorem to prove your answer algebraically.



Answer:

It was found in the experiment that both the given circuit in the question are equivalent.

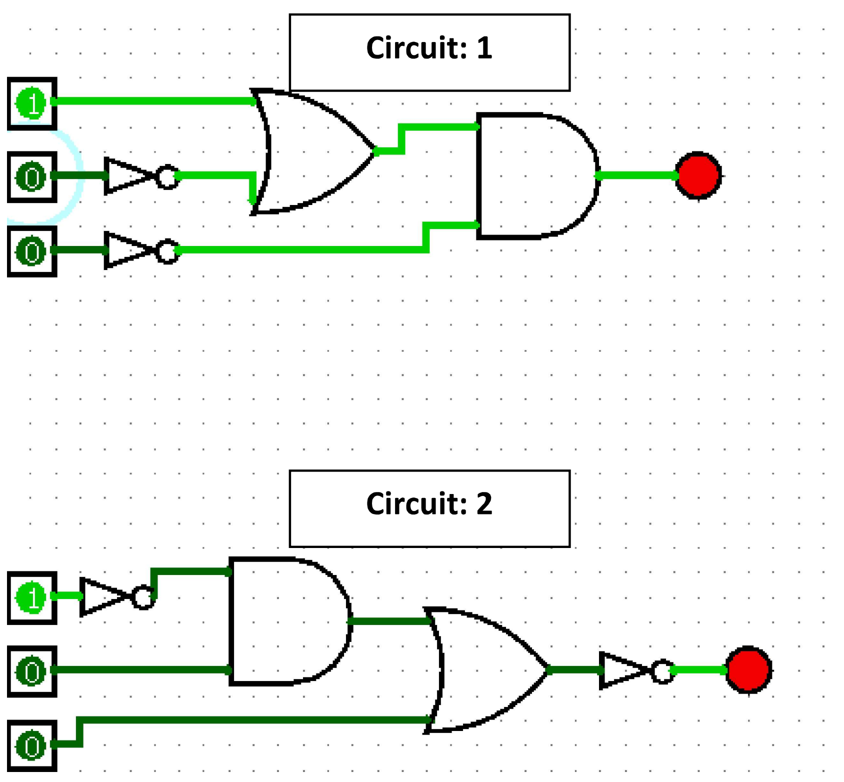


Figure : Question 2 Experimental Verification

Verification Using De-Morgan's Law:

From Circuit#1 :-

$(A + B').C'$

→ Applying Distribution.

$\boxed{AC' + B'C'} \longrightarrow *$

From Circuit #2:-

$((A'.B) + C)'$

→ Applying De-morgan's theorem.

$(A'.B)'.C'$

→ Again Applying De-morgan's theorem.

$(A + B').C'$

→ Apply Distribution.

$\boxed{AC' + B'C'} \longrightarrow *$

By comparing simplified form of both the expression from circuit 1 and circuit 2, it is clear that **both the given circuits are equivalent.** Since, expression from circuit 1 is equal to circuit 2 – that is,

$$AC' + B'C' = AC' + B'C'$$

Hence, Proved.

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