University of Engineering and Technology Peshawar

De-Morgan's Theorem

LAB # 03

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Class Section: **C**

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"On my honor, as student of University of Engineering and Technology, I have neither given nor received unauthorized assistance on this academic work."

Student Signature: ______________

Submitted to:

Engr. Rehmat Ullah

De-Morgan's Theorem

Objectives:

After completing this experiment, you will be able to:

- Know about the De-Morgan's theorems.
- To know the mathematical form.
- Haw to draw the circuit diagram and show the truth table.
- Experimentally verify the De-Morgan's theorems using two input variables.
- To verify the truth table of De-Morgan's theorem.

Equipment:

Dc power supply

Components:

- 7432 quad 2-input OR gate
- 7404 hex inverter
- LED
- 7408 quad 2-input AND gate
- DIP switch
- Two 280 Ω resistors
- Wires

Theory:

DE-MORGAN'S THEOREM

- (A + B)' = A'. B'................(a)
- (A . B)' = A' + B'...............(b)

Introduction:

De-Morgan's Theory:

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 operators.

De-Morgan's First Theorem:

De-Morgan's First theorem proves that when two (or more) input variables are AND'ed and negated, they are equivalent to the OR of the complements of the individual variables. Thus the equivalent of the NAND function will be a negative-OR function, proving that (A.B)' = A'+B'. We can show this operation using the following table.

Verifying De-Morgan's First Theorem using Truth Table:

Inputs		Truth Table Outputs For Each Term				
A	B	A.B	(A.B)'	$\overline{A}$	$\overline{B}$	$\overline{A} + \overline{B}$
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

We can also show that (A.B)' = A'+B' using logic gates as shown.

De-Morgan's First Law Implementation using Logic Gates:

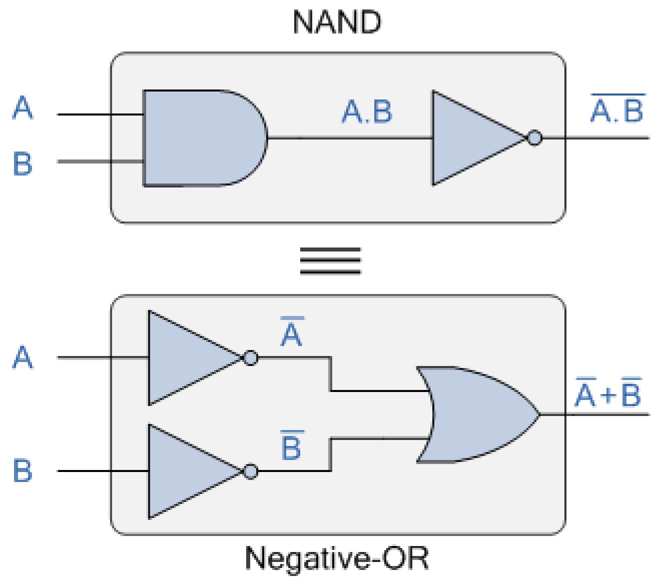


Figure 3.1

The top logic gate arrangement of:

(A.B)' can be implemented using a standard NAND gate with inputs A and B. The lower logic gate arrangement first inverts the two inputs producing A' and B'. These then become the inputs to the OR gate. Therefore the output from the OR gate becomes: A'+B'

Then we can see here that a standard OR gate function with inverters (NOT gates) on each of its inputs is equivalent to a NAND gate function. So an individual NAND gate can be represented in this way as the equivalency of a NAND gate is a negative-OR.

De-Morgan's Second Theorem:

De-Morgan's Second theorem proves that when two (or more) input variables are OR'ed and negated, they are equivalent to the AND of the complements of the individual variables. Thus the equivalent of the NOR function is a negative-AND function proving that (A+B)' = A' . B', and again we can show operation this using the following truth table.

Verifying De-Morgan's Second Theorem using Truth Table:

Inputs		Truth Table Outputs For Each Term				
A	B	A+B	(A+B)'	$\overline{A}$	$\overline{B}$	$\overline{A} . \overline{B}$
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

We can also show that (A+B)' = A'. B' using the following logic gates example.

De-Morgan's Second Law Implementation using Logic Gates

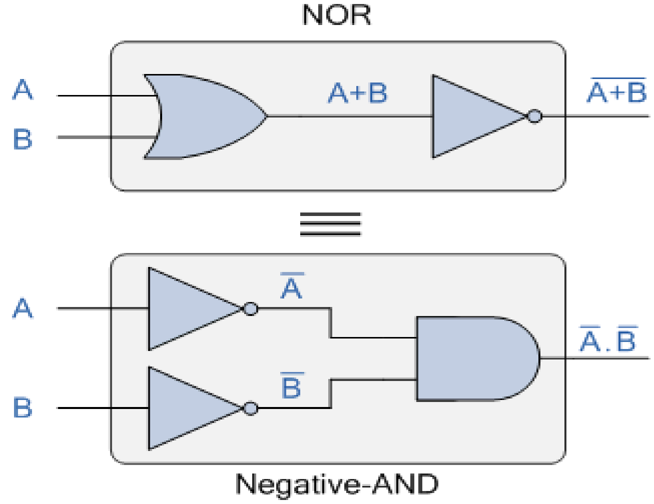


Figure 3.2

The top logic gate arrangement of:

(A+B)' can be implemented using a standard NOR gate function using inputs A and B. The lower logic gate arrangement first inverts the two inputs, thus producing A' and B'. Thus then become the inputs to the AND gate. Therefore the output from the AND gate becomes: A' . B'

Then we can see that a standard AND gate function with inverters (NOT gates) on each of its inputs produces an equivalent output condition to a standard NOR gate function, and an individual NOR gate can be represented in this way as the equivalency of a NOR gate is a negative-AND.

Although we have used De-Morgan's theorems with only two input variables A and B, they are equally valid for use with three, four or more input variable expressions, for example:

For a 3-variable input

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

and also

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

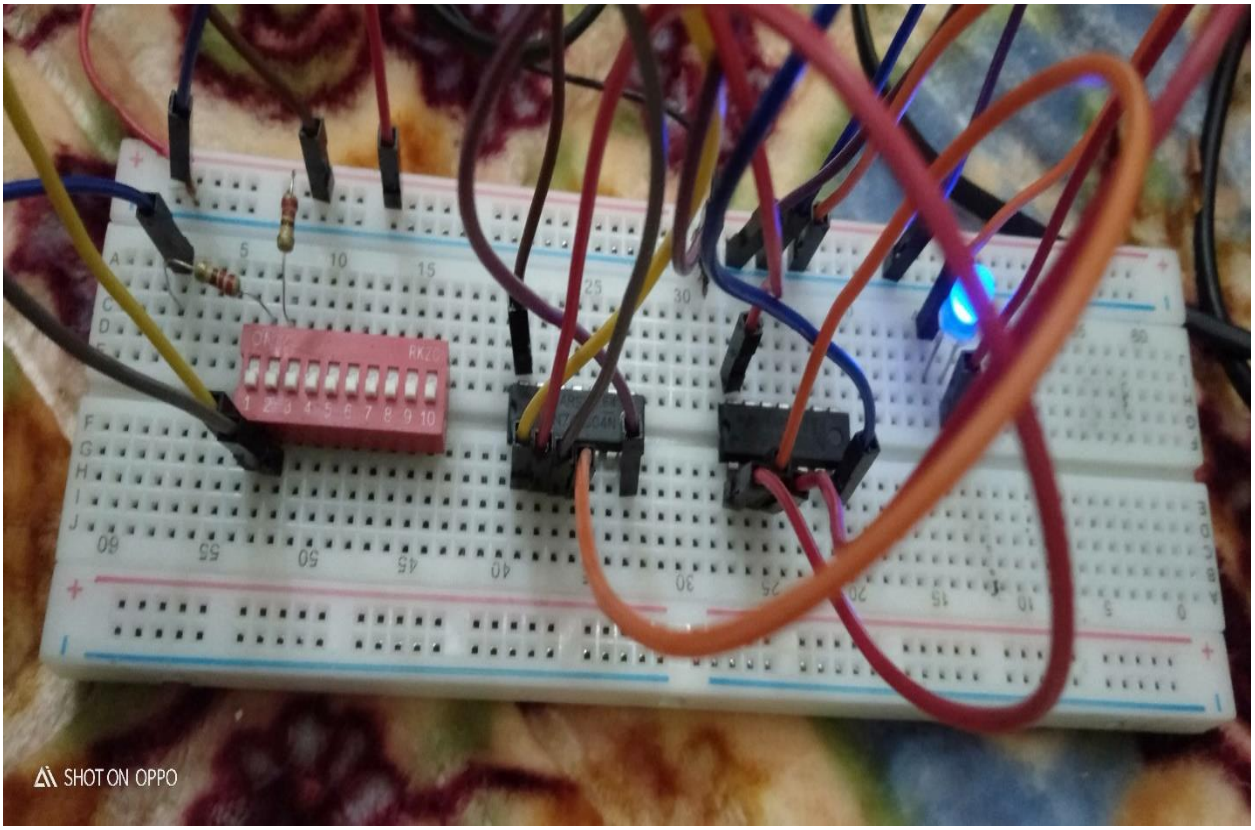
Procedure:

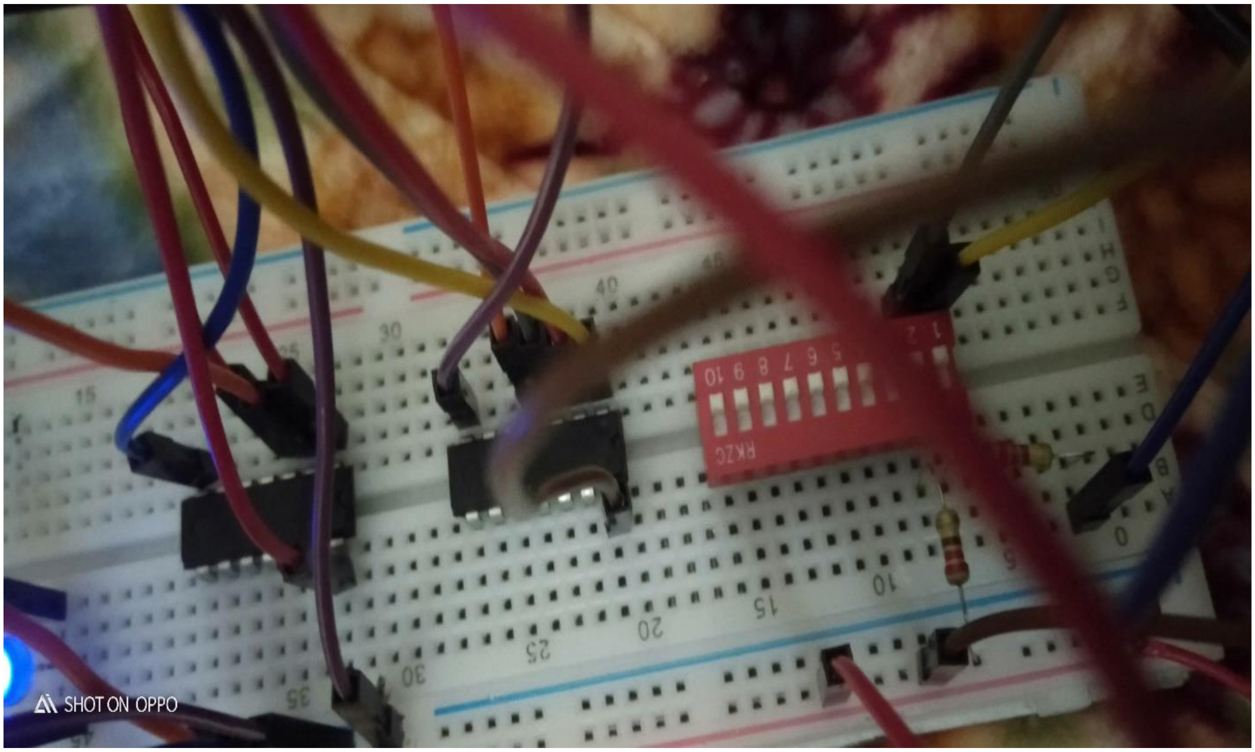
- Build the circuit for left part of equation (a) as shown in figure 3.1 and monitor the behavior of LED for different test inputs
- Then complete the circuit of figure 3.1 for the right part of equation (a) and complete the truth table 3.1 by testing each combination of inputs of appropriate switches
- Compare both the column results and check whether equation (a) is verified or not
- Repeat the above process by building the circuits of figure 3.2 and comparing its results for De-Morgan's theorem verification of equation (b).

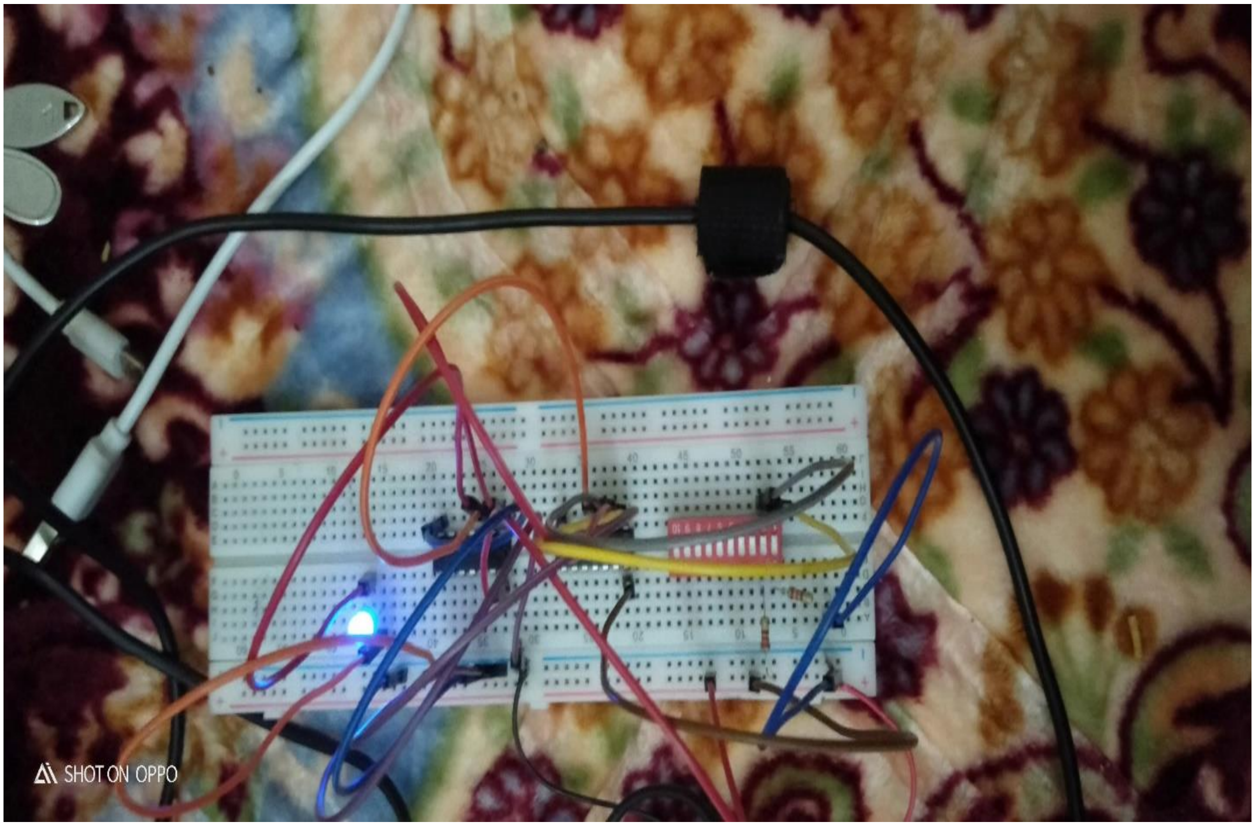
Observation and Calculation:

We can verify the above truth table in experimentaly.

See below the image to verify the De-Morgan's theorem.




SHOT ON OPPO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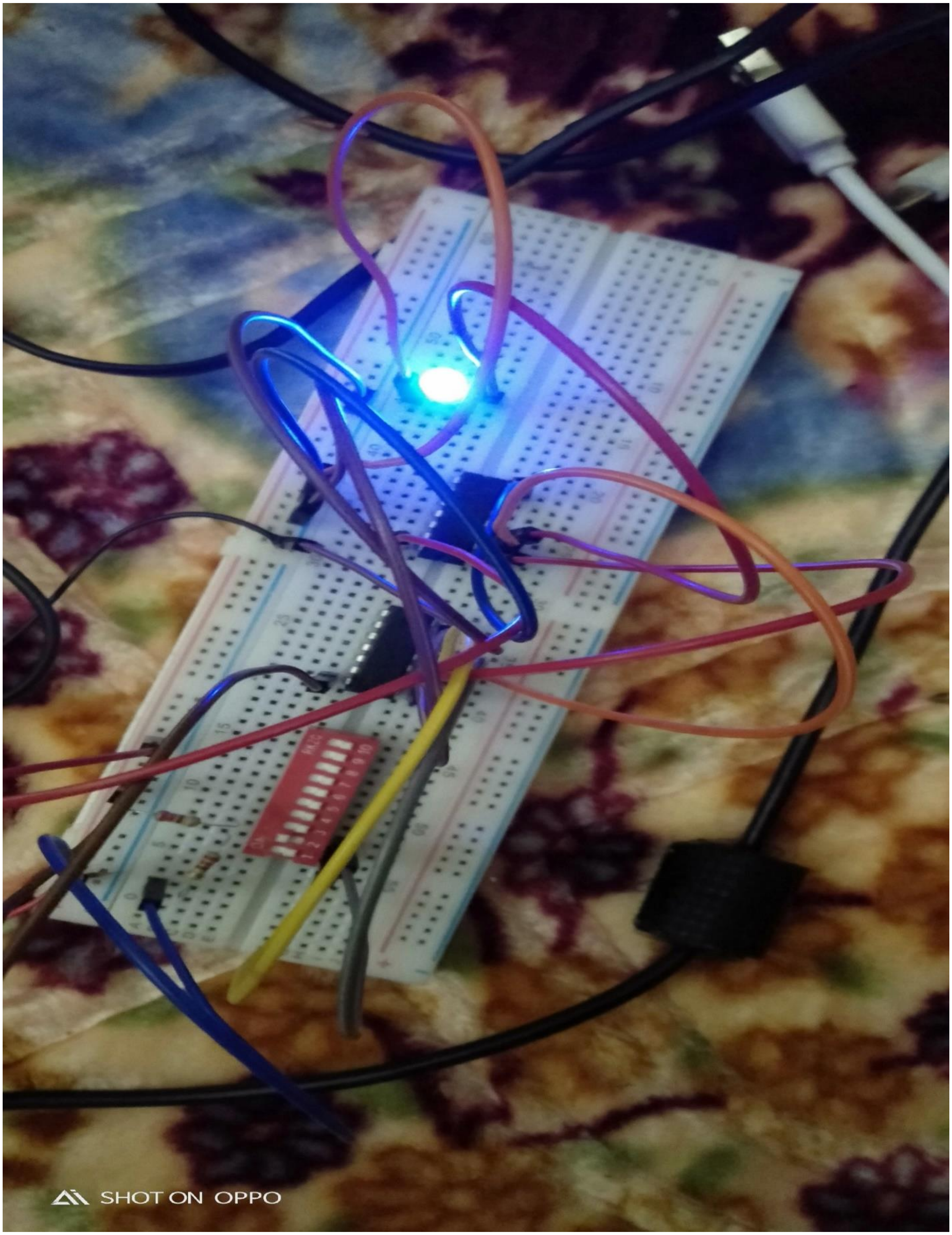
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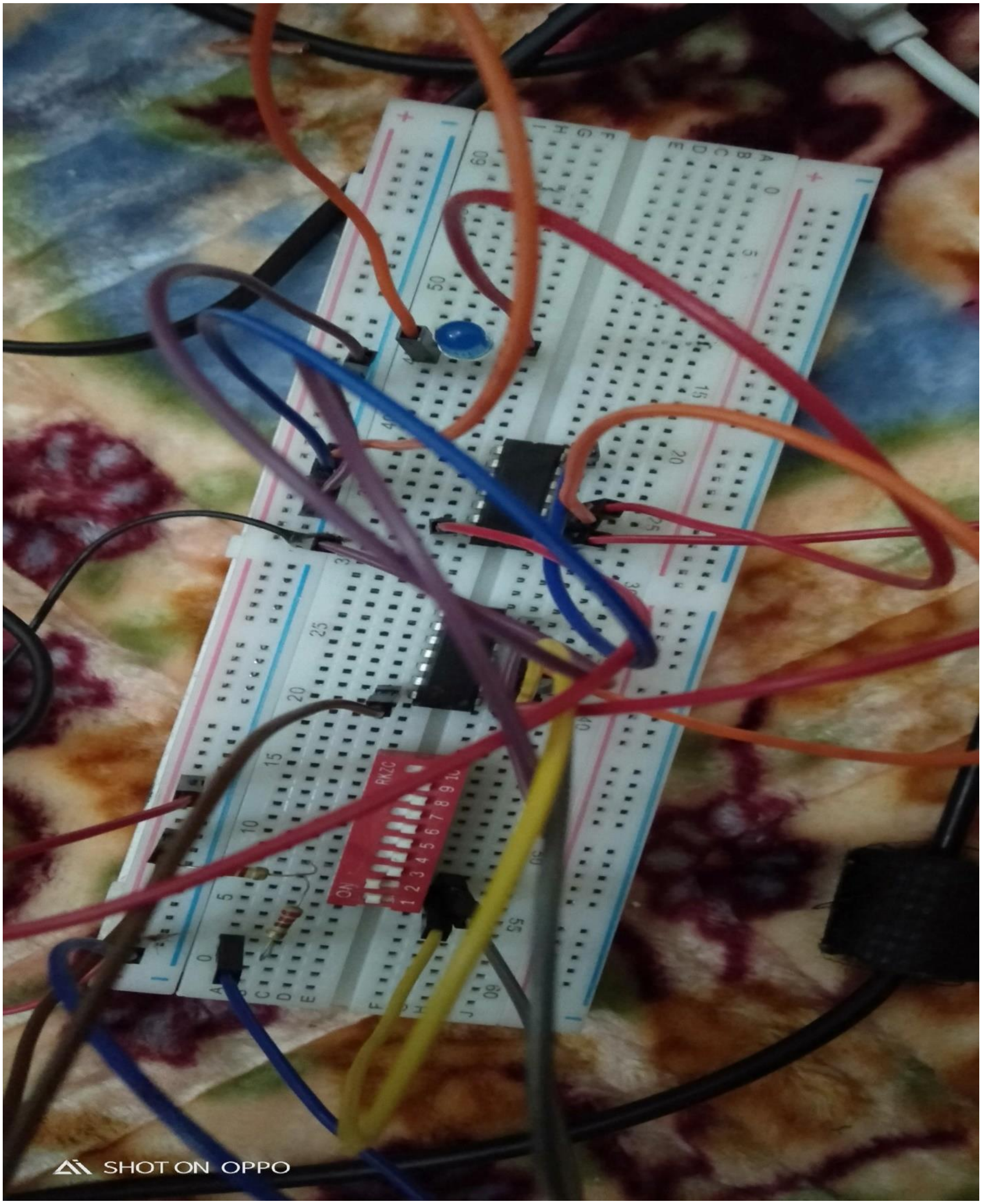


CONCLUSION:

We know the De-Morgan's thoerem and the mathematical form, logical circuit and truth table.

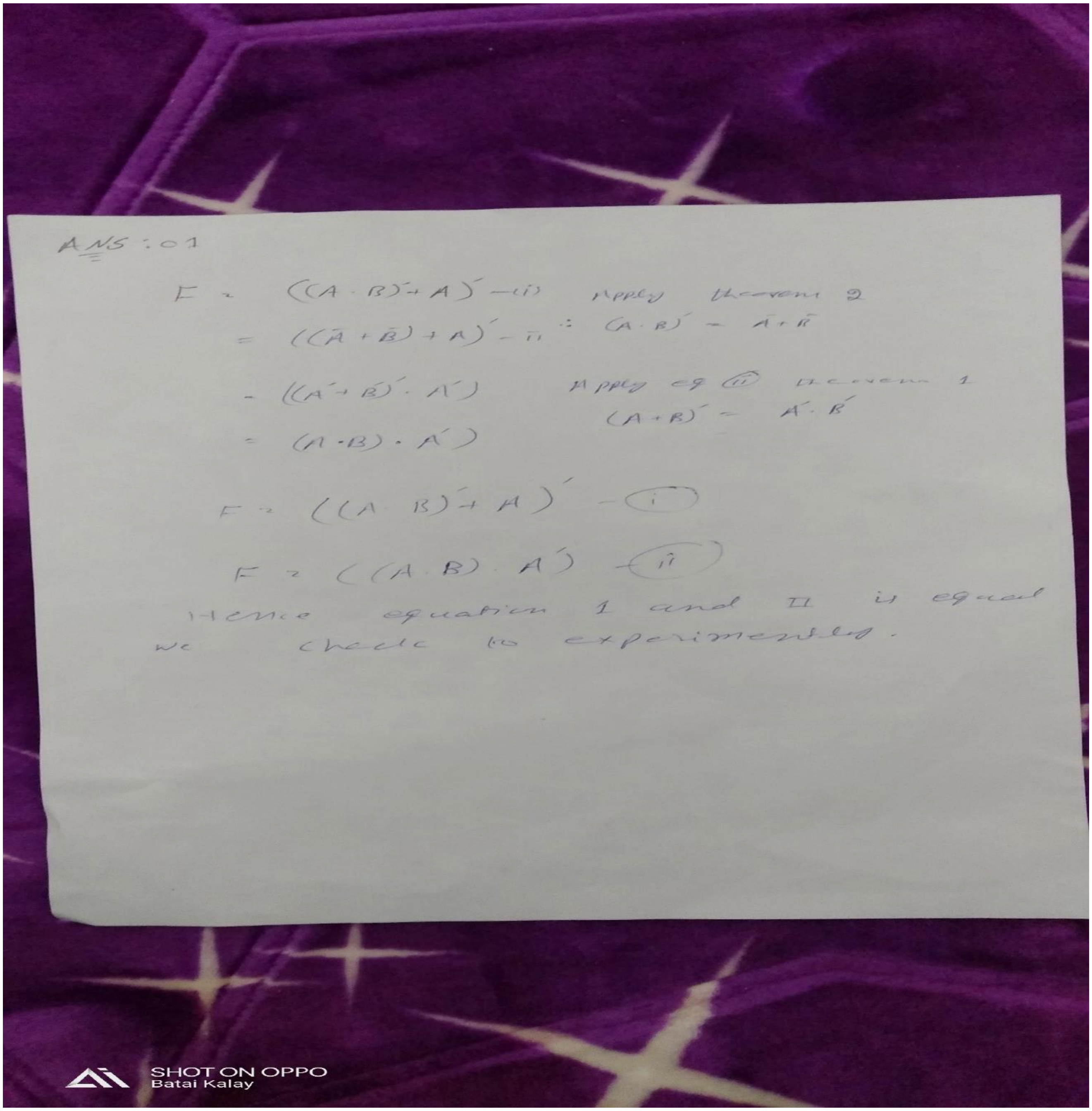
That verified by experiment show the above images.

REVIEW QUESTIONS:

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

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

ANS:



ANS : 01

$F = ((A \cdot B)' + A)'$ —(i) Apply theorem 2

$= ((A' + B') + A)'$ — ii ∵ $(A \cdot B)' = A' + B'$

$= ((A' + B')' \cdot A')$ Apply eq (ii) theorem 1

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

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

$F = ((A \cdot B)' + A)'$ — (i)

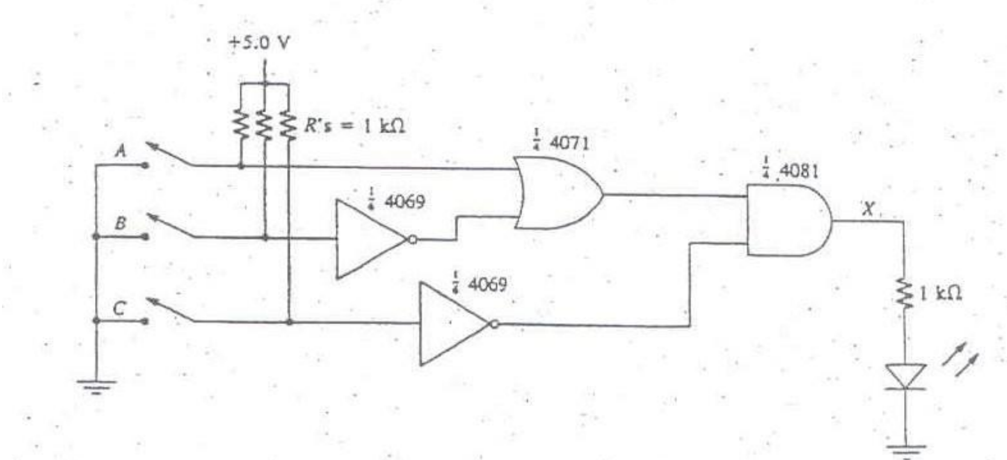
$F = ((A \cdot B) \cdot A')$ — (ii)

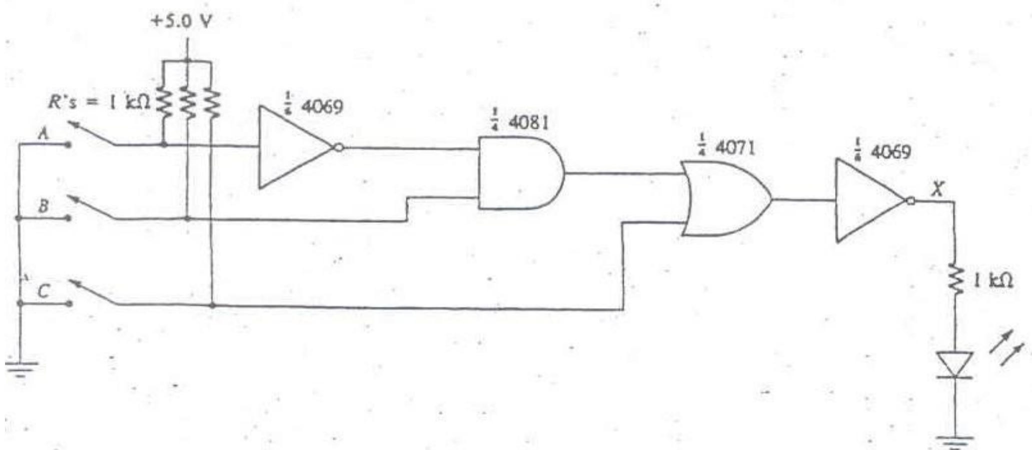
Hence equation 1 and II is equal
we check to experimentally.

Truth Table :

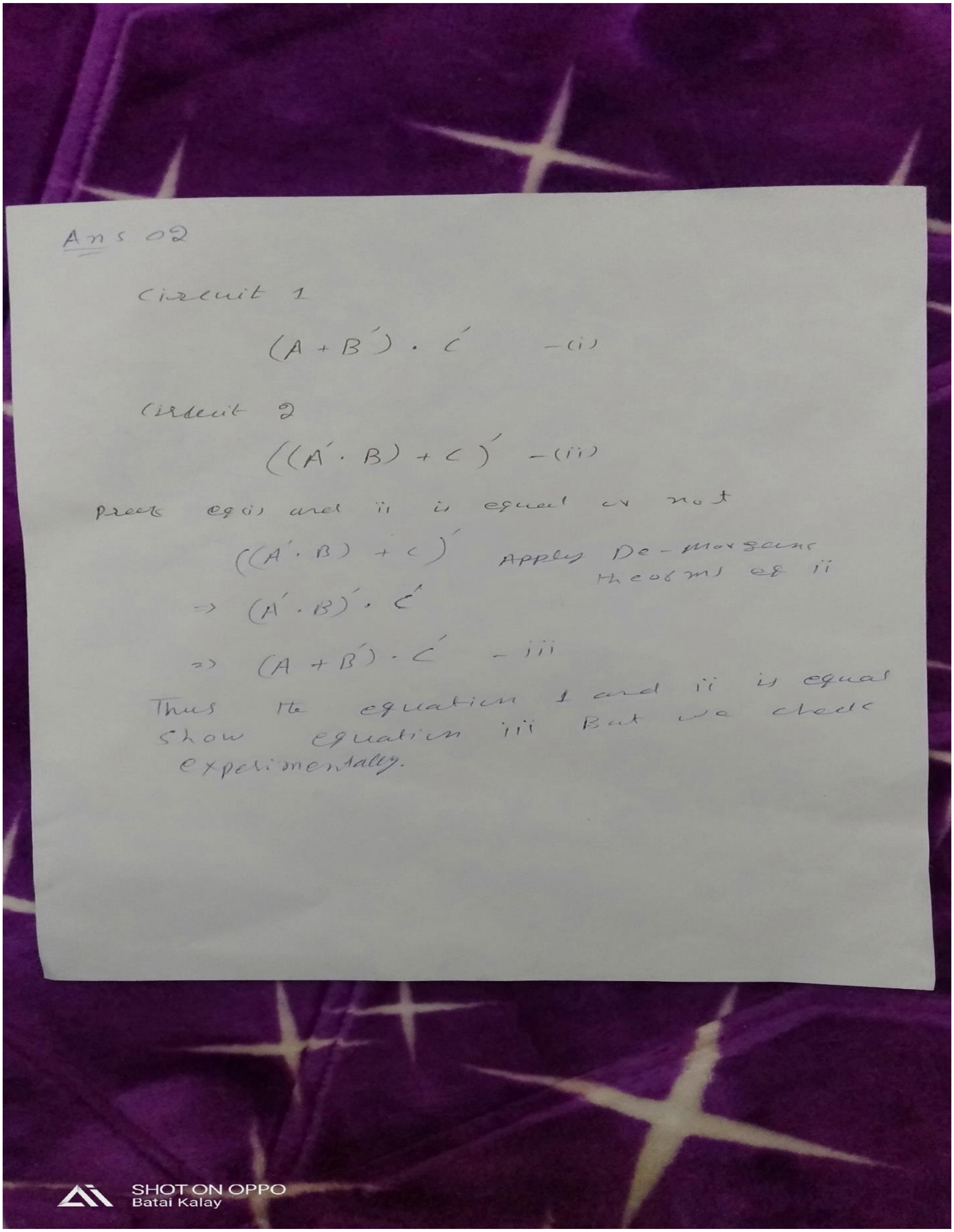
A	B	A.B	(A.B)’	(A.B)’+A	((A.B)’+A)’	A’	(A.B).A’
0	0	0	1	1	0	1	0
0	1	0	1	1	0	0	0
1	0	0	1	1	0	1	0
1	1	1	0	1	0	0	0

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





ANS 02:



Ans 02

Circuit 1

$(A + B') \cdot C'$ — (i)

Circuit 2

$((A' \cdot B) + C)'$ — (ii)

Proofs eq (i) and ii is equal or not

$((A' \cdot B) + C)'$ Apply De-Morgans theorms of ii

$\Rightarrow (A' \cdot B)' \cdot C'$

$\Rightarrow (A + B') \cdot C'$ — iii

Thus the equation 1 and ii is equal show equation iii But we check experimentally.

Truth Table:

Circuit 1:

A	B	C	B’	A+B’	C’	(A+B’).C’
0	0	0	1	1	1	1
0	0	1	1	1	0	0
0	1	0	0	0	1	0
0	1	1	0	0	0	0
1	0	0	1	1	1	1
1	0	1	1	1	0	0
1	1	0	0	1	1	1
1	1	1	0	1	0	0

Circuit 2:

A	B	C	A’	A’.B	(A’.B)+C	((A’.B)+C)
0	0	0	1	0	0	1
0	0	1	1	0	1	0
0	1	0	1	1	1	0
0	1	1	1	1	1	0
1	0	0	0	0	0	1
1	0	1	0	0	1	0
1	1	0	0	0	0	1
1	1	1	0	0	1	0