TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
PULCHOWK CAMPUS
Lab Sheet 2

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Familiarisation with NAND and NOR Gates

Objectives

The objectives of this experiment are:

- To become familiarized with NAND and NOR gates
- To prove De-Morgan’s theorem
- To show NAND and NOR gates are universal logic gates.

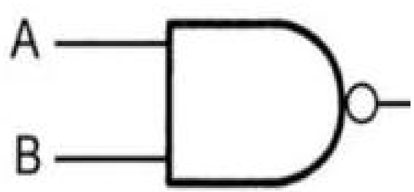
Theory:

Introduction:

Among different types of logic gates, we will be dealing with two logic gates:

I. NAND Gate: This gate is formed by the inversion of AND gate. It is formed by the combination of an AND gate followed by a NOT gate. Its circuit diagram and truth table is given below:

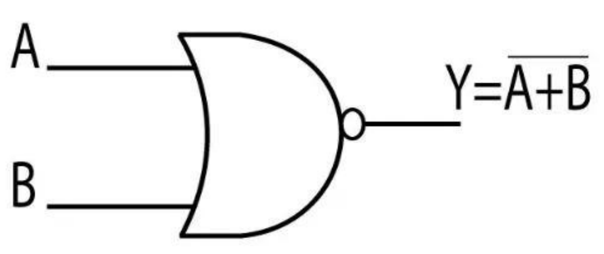
$$X = \overline{A.B}$$



A	B	X
0	0	1
0	1	1
1	0	1
1	1	0

As we can see in the above table, if at least one input is low, output will be high. Similarly, for the output to be low, all input must be low.

II. NOR Gate: NOR gate is the combination of an OR gate followed by NOT gate. Its result is the inverse of the NOT gate. Its logic gate and truth table are given below.



A	B	Y
0	0	1
0	1	0
1	0	0
1	1	0

In NOR gate, output will be low if at least one of the inputs is high.

De-Morgan's Theorem:

1. De-Morgan's First Law: De-Morgan's first law states that, "The complement of a product of variables is equal to the sum of the complements of the variables". i.e. (A.B)' = A' + B'

Since, (A.B)’ represents the output of a two input NAND gate with inputs A and B, and A’ + B’ represents the output of a two input OR gate with inputs A and B inverted, we can say that a NAND gate is equivalent to a negative OR gate.

2. De-Morgan’s Second Law: De-Morgan’s second law states that, “The complement of a sum of variables is equal to the product of the complements of the variables.” i.e. (A+B)’ = A’.B’

   Since, (A+B)’ represents the output of a two terminalNOR gate with A and B as the inputs and A’.B’ is the output of a two terminal AND gate with the inputs A and B both inverted,we can say that a NOR gate is equivalent to a negative AND gate.

Universal and Fundamental Logic Gates:

Fundamental logic gates are those gates that can be combined together to form any of the boolean expressions. The three fundamental logic gates are AND, OR and NOT.

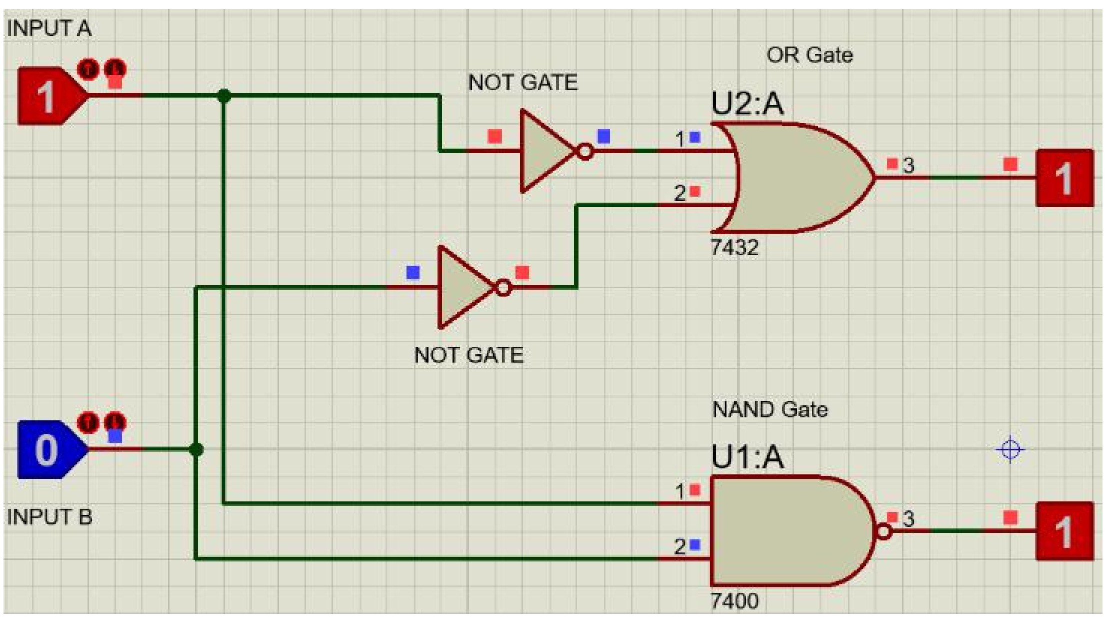
Universal logic gates are those gates that can be used separately to form any of the fundamental gates and hence the boolean expressions. Universal logic gates are NAND and NOR.

Procedure and Observation:

- **De-Morgan's Theorem:**

First Theorem: ((A.B)' = A' + B')

To prove this theorem, the inputs were first connected two a NOR gate and the same inputs were connected to separate inverters and then to an AND gate. Then the output from AND gate and NOR gate were observed.



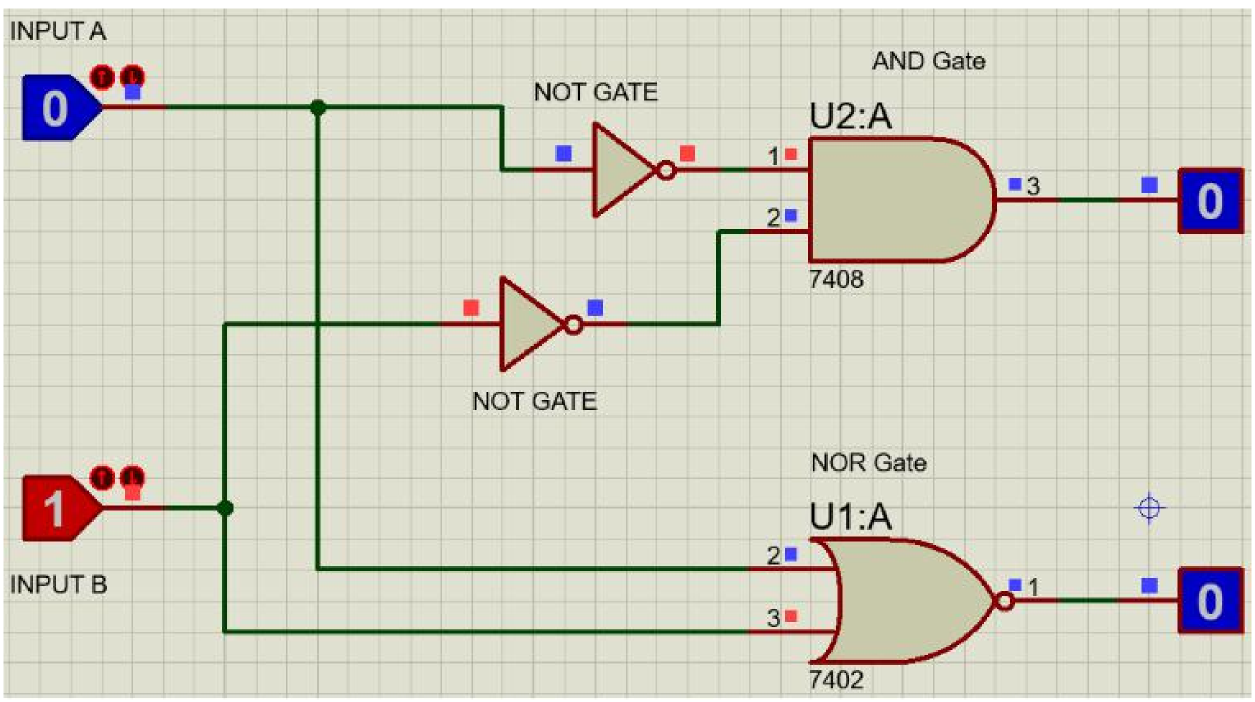
Following truth table was obtained:

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

0	1	1	1
1	0	1	1
1	1	0	0

This proves that a two input NAND gate is equivalent to a two input negative OR gate

Second Theorem: ((A+B)' = A'.B')
To prove this theorem, the inputs were first connected two a NOR gate and the same inputs were connected to separate inverters and then to an AND gate. Then the output from AND gate and NOR gate were observed.



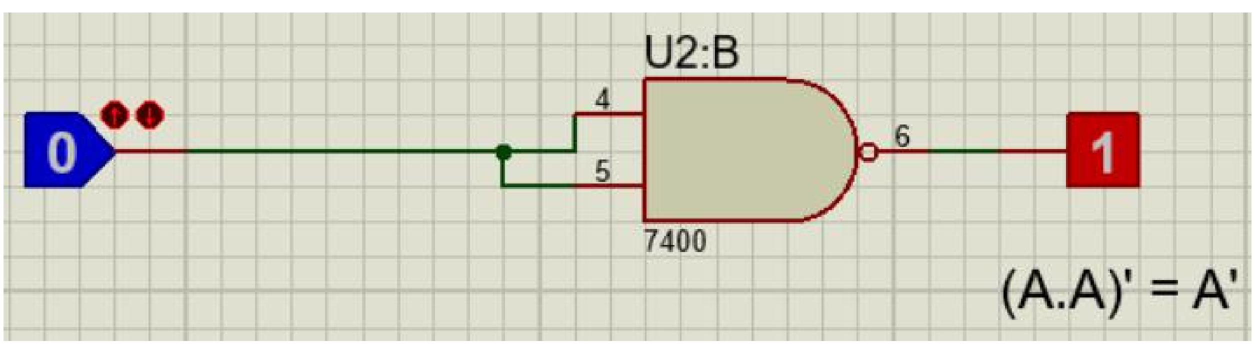
Following truth table was obtained from the experiment:

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

This proves that a two input NOR gate is equivalent to a two input negative AND gate.

- **NAND and NOR as Universal Logic Gates:**

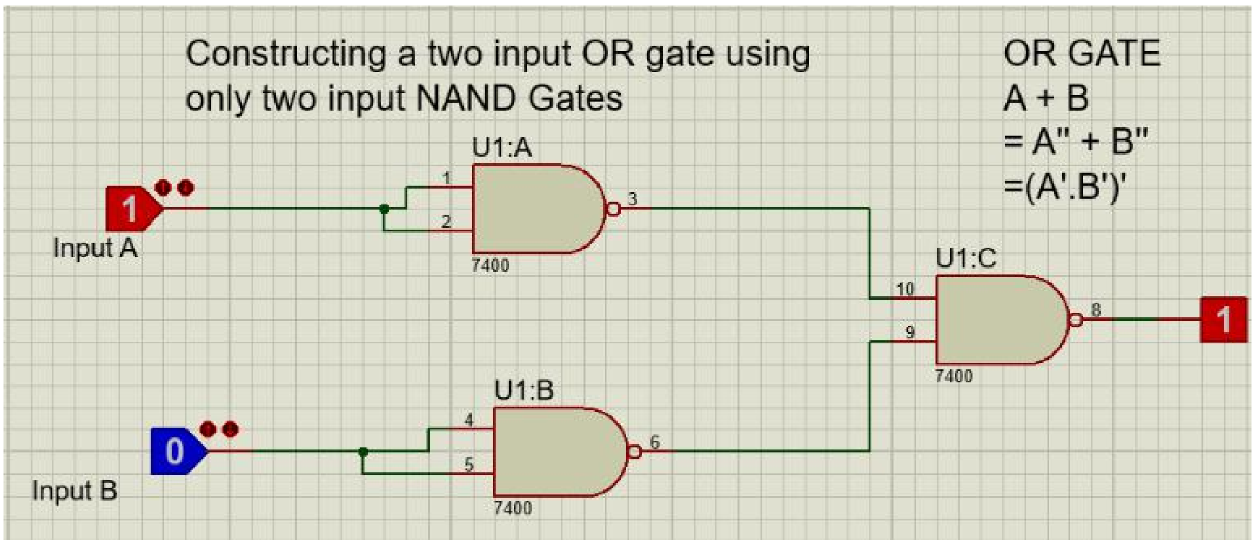
NAND GATE:
NOT gate using NAND gate:



Following truth table was obtained:

A	A’	(A.A)’
0	1	1
1	0	0

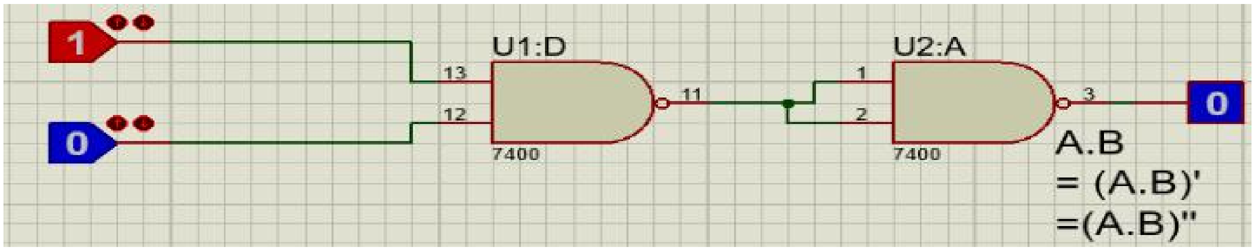
OR gate using NAND Gate:



Truth Table:

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

AND using NAND:



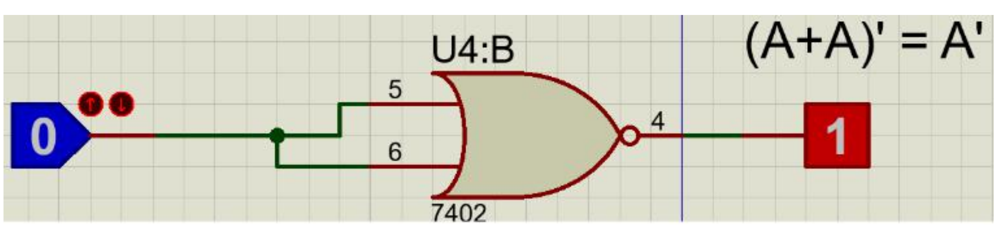
Truth Table:

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

In this way, fundamental logic gates were formed using NAND gate.

NOR Gate:

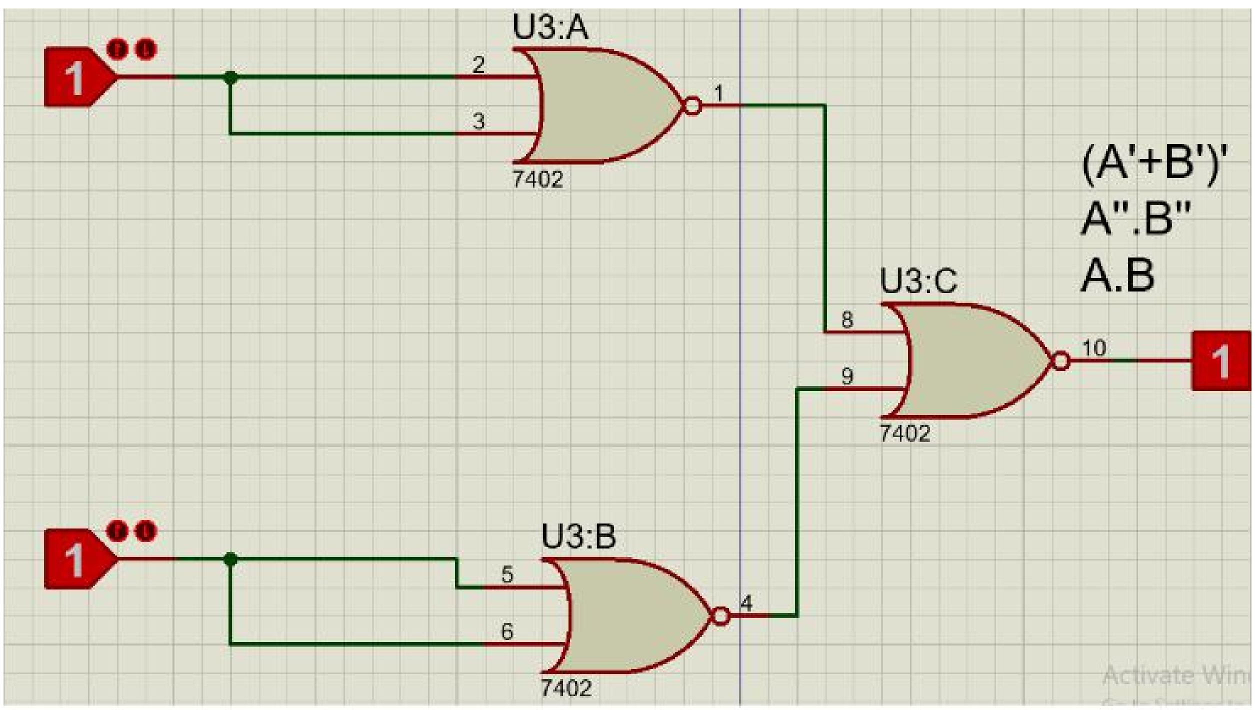
NOR gate as NOT gate:



Truth Table:

A	A’	(A+A)’
0	1	1
1	0	0

NOR Gate as AND Gate:

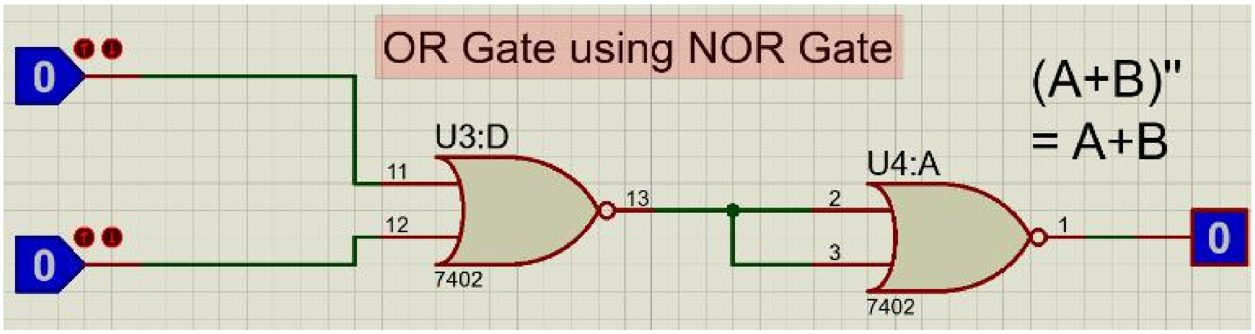


Truth Table:

A	B	A.B	(A’ + B’)’
0	0	0	0

0	1	0	0
1	0	0	0
1	1	1	1

NAND Gate as OR Gate:



Truth Table:

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

In this way, all fundamental logic gates are formed by using NOR gate.

Discussion: In this way, we can use the ‘Proteus’ to design and build different logic gates and simulate their output. No errors were obtained during the experiment as the simulation was done using the computer software.

Conclusion: In this way, we can prove the De-Morgan’s theorem. Similarly, NAND and NOR gate can be combined separately to form any of the fundamental logic gates.