Aim:

To implement the logic functions i.e. AND, OR, NOT, Ex-OR, Ex-NOR and a logical expression with the help of NAND and NOR universal gates respectively

Theorey:

Logic gates are electronic circuits which perform logical functions on one or more inputs to produce one output. There are seven logic gates. When all the input combinations of a logic gate are written in a series and their corresponding outputs written along them then this input/output combination is called Truth table.

1.) Nand gate as Universal gate

NAND gate is actually a combination of two logic gates i.e. AND gate.

followed by NOT gate. So its output is complement of the output of an AND gate. This gate can have minimum two inputs. By using only NAND gates, we can realize all logic functions AND, OR, NOT, Ex-OR, Ex-NOR, NOR. So this gate is also called as universal gate.

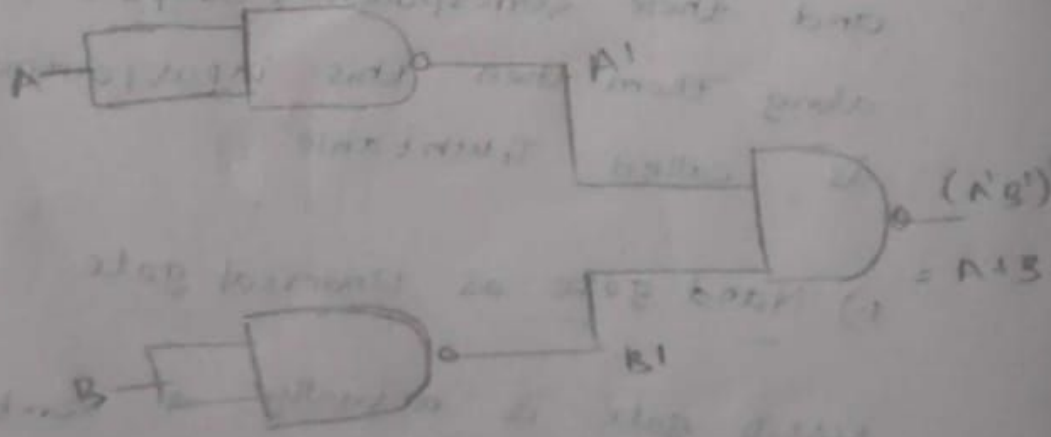
a.) NAND gates as OR gate

From DeMorgans theorems

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

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

So give the inverted inputs to a NAND gate, obtain OR operation at output.



OR

NAND gates as OR gate

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

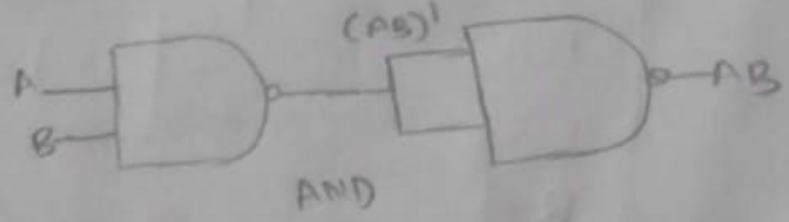
Truth table of OR

b.) NAND gates as AND gate

A NAND produces complement of AND gate. So, if the output of a NAND gate is inverted, overall output will be that of an AND gate.

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

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



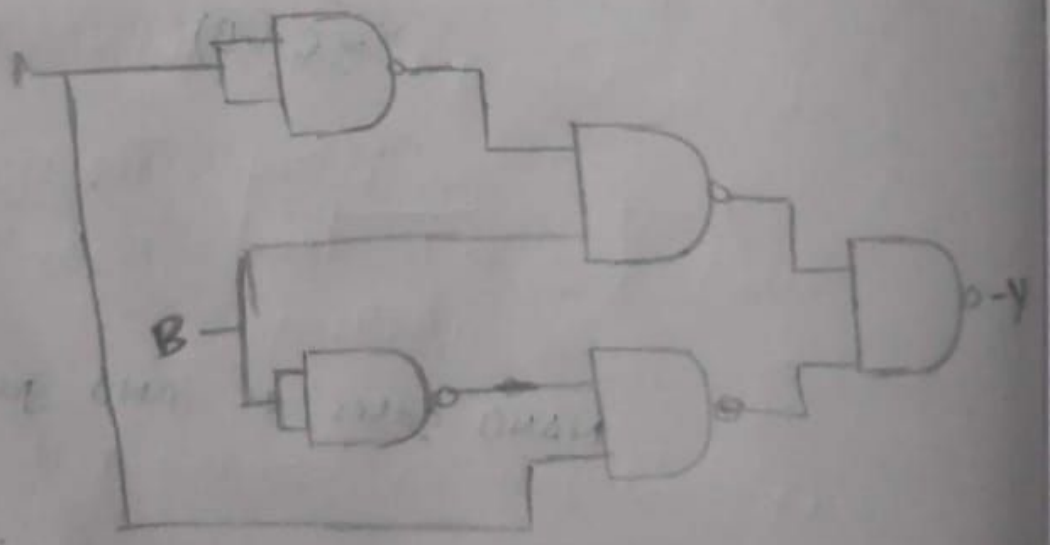
NAND gates as AND gate.

Input		output
A	B	Y=A·B
0	0	0
0	1	0
1	0	0
1	1	1

Truth table of AND.

c.) NAND gates as Ex-OR gate.

The output of a two input Ex-OR gate is shown by $Y = A'B + AB'$. This can be achieved with the logic diagram shown in the left side.



NAND gate as Ex-OR gate.

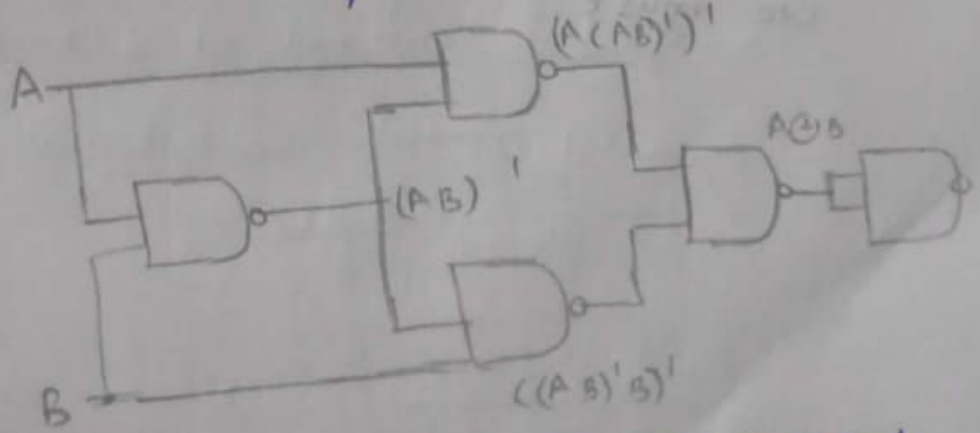
A	B	A XOR B
0	0	0
0	1	1
1	0	1
1	1	0

Truth table of Ex-OR

d-) NAND gates as Ex-NOR gate

Ex-NOR gate is actually Ex-OR gate followed by NOT gate. So give the output of Ex-OR gate to a NOT gate, overall input is that of an Ex-NOR gate.

$Y = AB + A'B'$



NAND gates as Ex-NOR gate

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

Truth table of Ex-NOR

e.) Implementing the simplified function with NAND gates only

We can now start constructing the circuit. First note that the entire expression is inverted and we have three terms ANDed. This means that we must

2) NOR gate is Universal gate

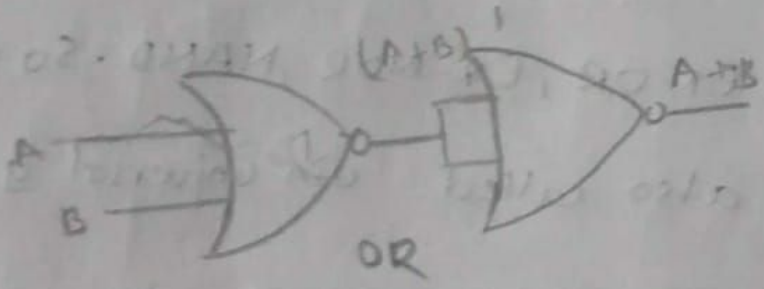
NOR gate is actually a combination of two logic gates, OR gate followed by NOT gate. So its output of an OR gate. This gate can have minimum two inputs, output is always one. By using only NOR gates, we can realize all logic functions. AND, OR, NOT, Ex-OR, Ex-NOR, NAND. So this gate is also called ~~a~~ universal gate.

a.) NOR gates as OR gate

A NOR produces complement of OR gate, So if the output of a NOR gate is inverted, overall output will be that of an OR gate.

$$Y = ((A+B)')'$$

$$Y = (A+B)$$



NOR gates as OR gate.

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

b)

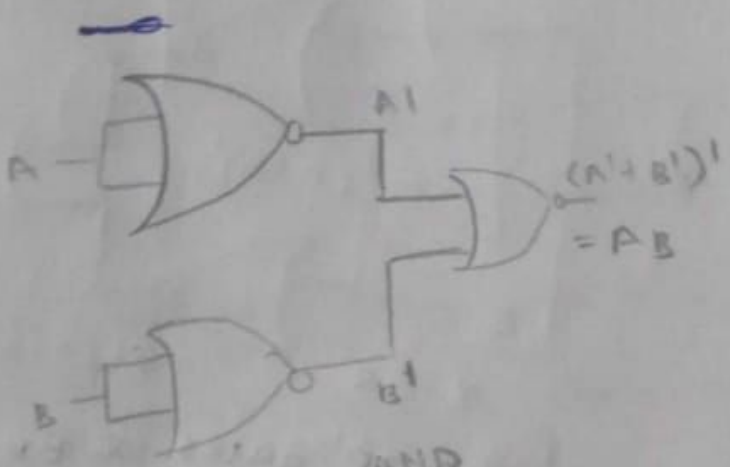
NOR gates as AND gate

From DeMorgan's theorems

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

$$(A'+B')' = A'B' + AB$$

So, give the inverted outputs to a NOR gate, obtain AND operation at output



NOR gates as AND gate.

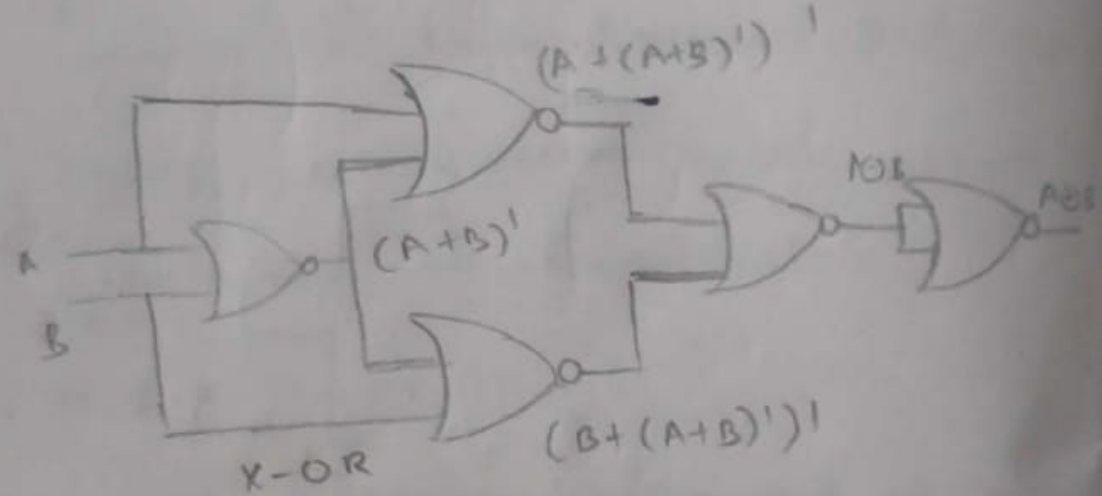
A	B	AxorB
0	0	0
0	1	1
1	0	1
1	1	0

Truth table of Ex-OR

(iii) NOR gates as Ex-OR gate

Ex-OR gate is actually Ex-NOR gate following by NOT gate. So give the output of Ex-NOR gate to a NOT gate, overall output is that of an Ex-OR gate.

$$Y = A'B + AB'$$



NOR gates as Ex-OR gate

A	B	A XOR B
0	0	0
0	1	1
1	0	1
1	1	0

Truth table of Ex-OR

d.) NOR gates as Ex-NOR gate

The output of a two input Ex-NOR gate is shown by $Y = AB + A'B'$. This can be achieved with the logic diagram shown in the left

Gate No.	Inputs	output
1	$A \cdot B$	$(A+B)'$
2	$A \cdot (A+B)'$	$(A+(A+B)')'$
3	$(A+B)' \cdot B$	$(B+(A+B)')'$
4	$(A+(A+B)')'$, $(B+(A+B)')'$	$AB + A'B'$

Now the output from gate no 4 is overall input of the configuration

$$Y = \left((A+(A+B)')' \; (B+(A+B)')' \right)'$$

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

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

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

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

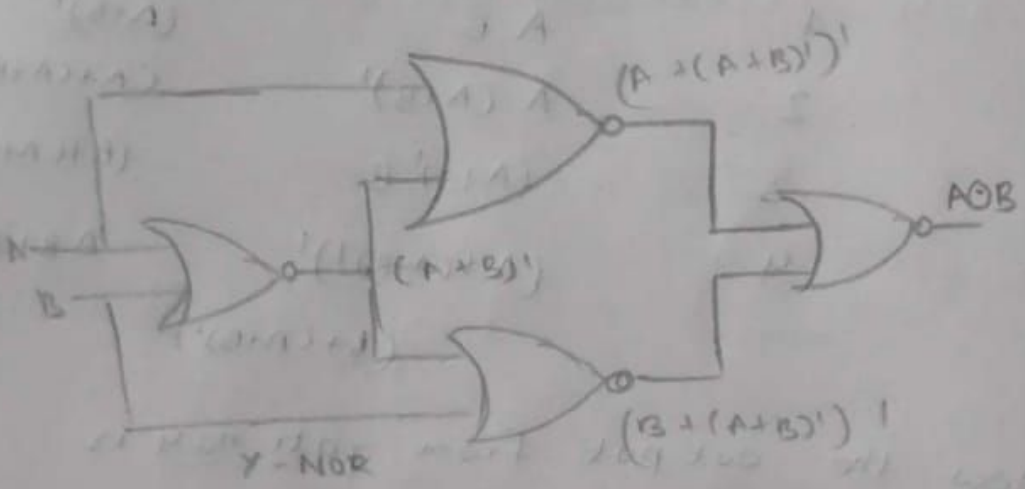
$$= (A+A') \cdot (A+B')(B+A')(B+B')$$

$$= 1 \cdot (A+B') \cdot (B+A') \cdot 1$$

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

$$= AB + 0 + 0 + B'A'$$

$$\Rightarrow \boxed{Y = AB + A'B}$$



NOR gates as Ex-NOR gate

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

Truth Table of NOR gate only.

100) c) Constructing a circuit with NOR gates only

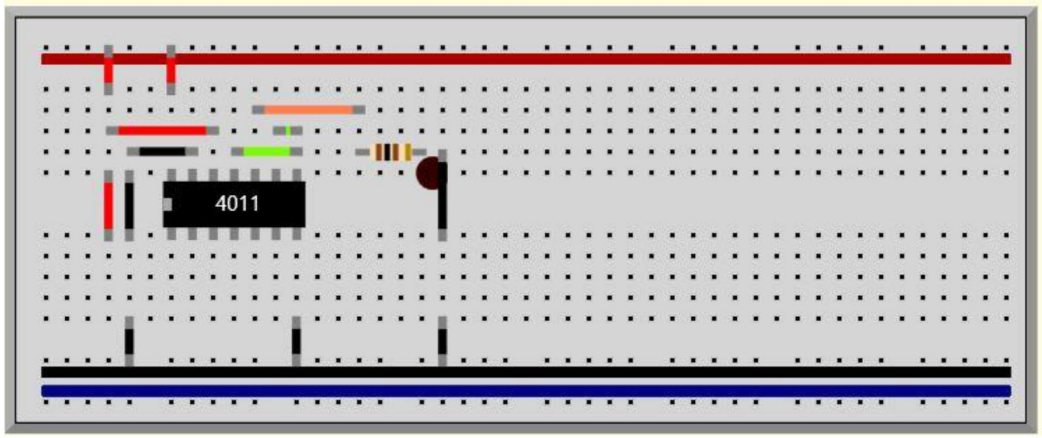
Designing a circuit with NOR gates only uses the same basic techniques as designing the a circuit with NAND gates, that is the application of demorgan's theorem. The only difference between NOR gate design and NAND gate design is the former must eliminate product terms and the later must be eliminate sum terms.

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

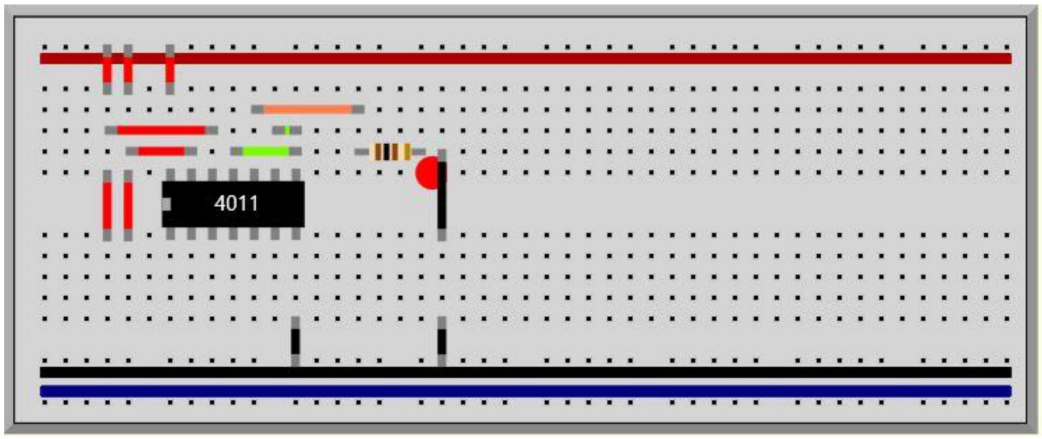
USING NAND

AND

Input:1 0 Output:0

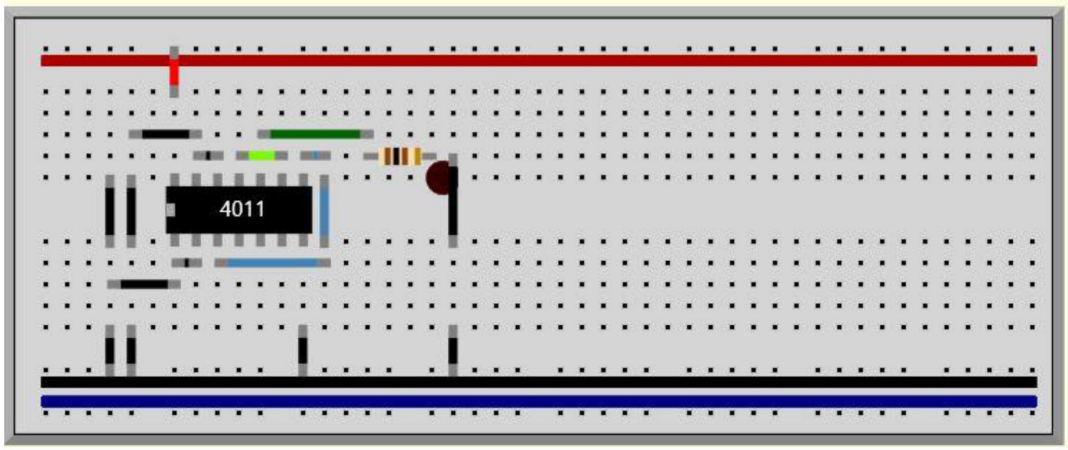


Input : 1 1 Output:1

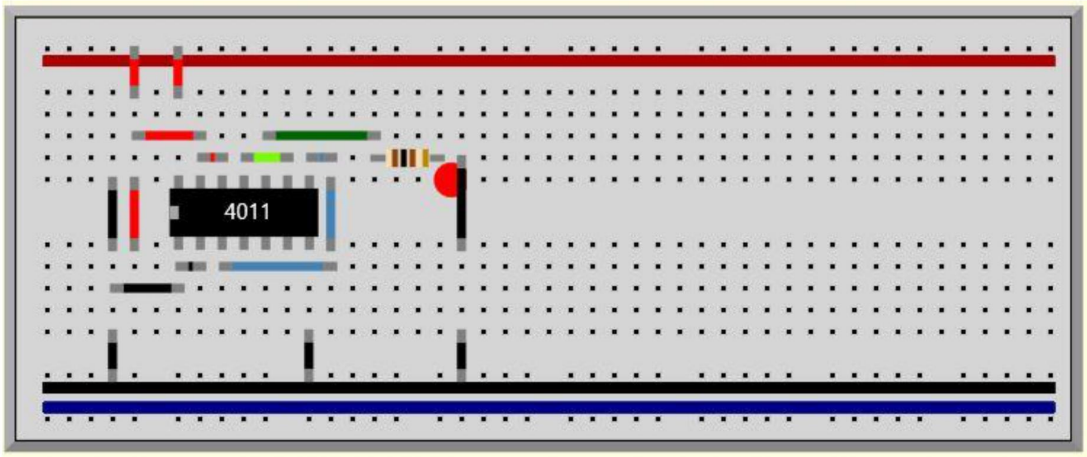


OR Gate

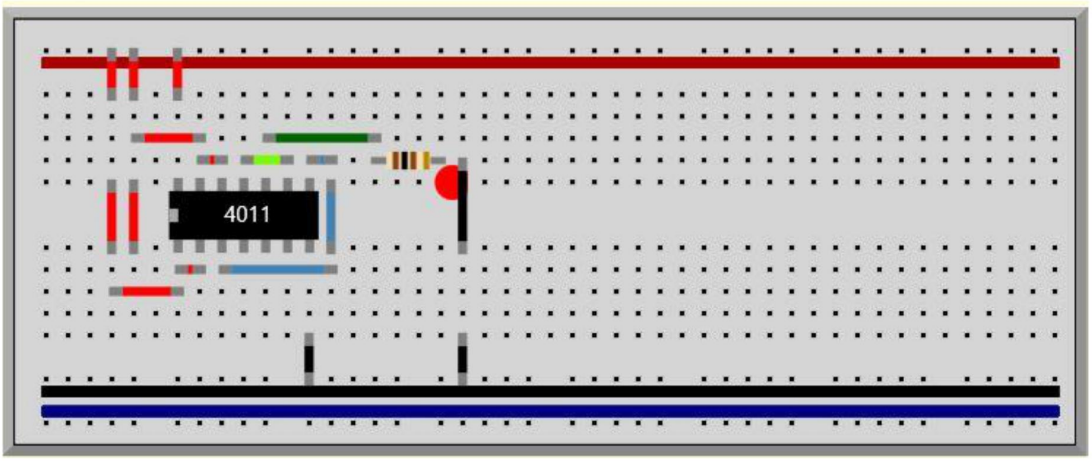
Input:0 0 Output:0



Input:1 0 Output:1

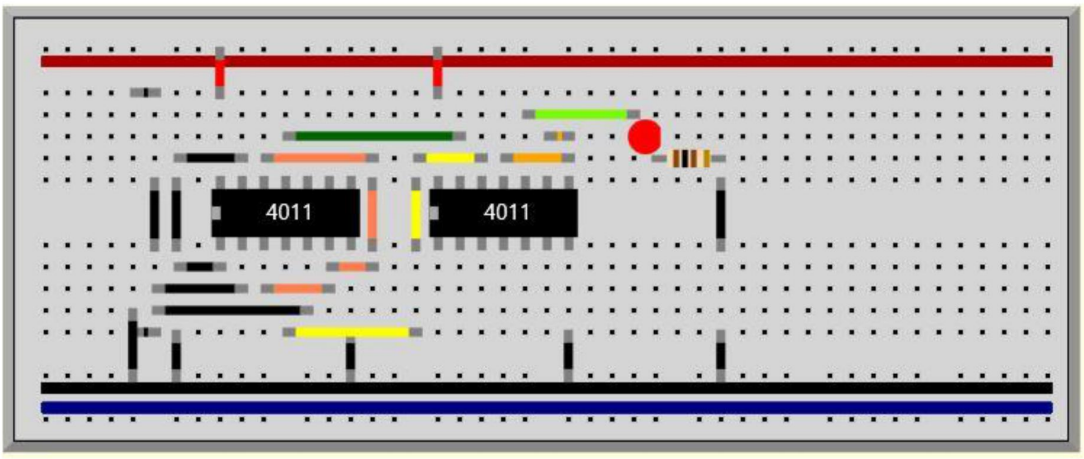


Input:1 1 Output:1

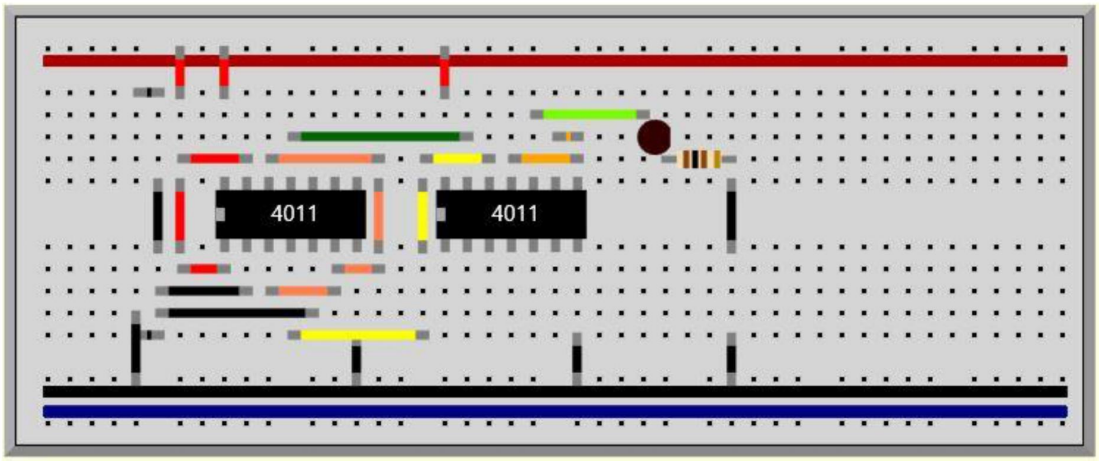


XNOR

Input:0 0 Output:1

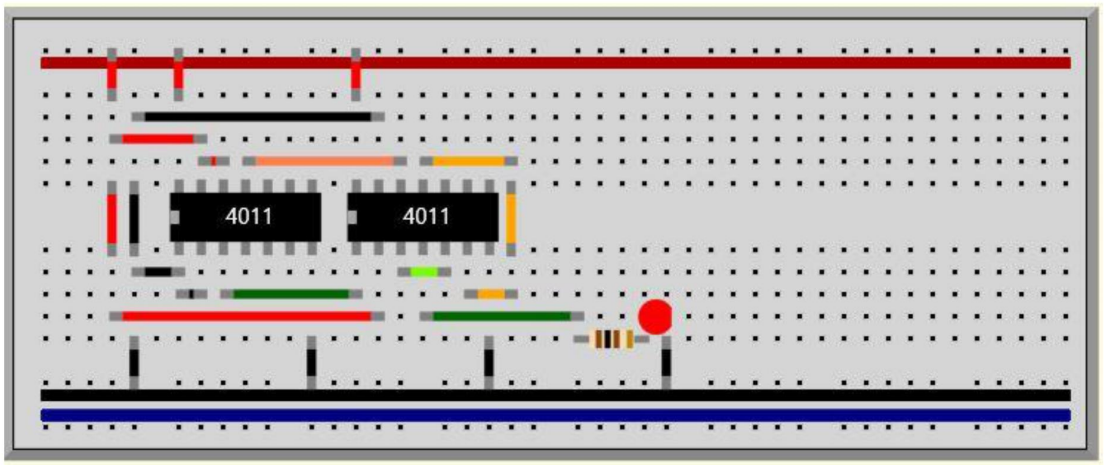


Input:1 0 Output:0

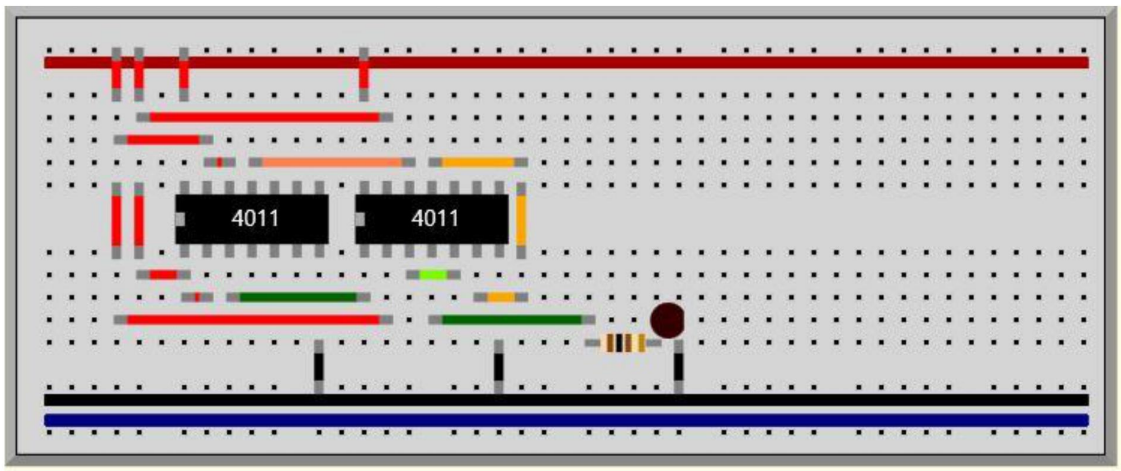


XOR

Input:1 0 Output:1



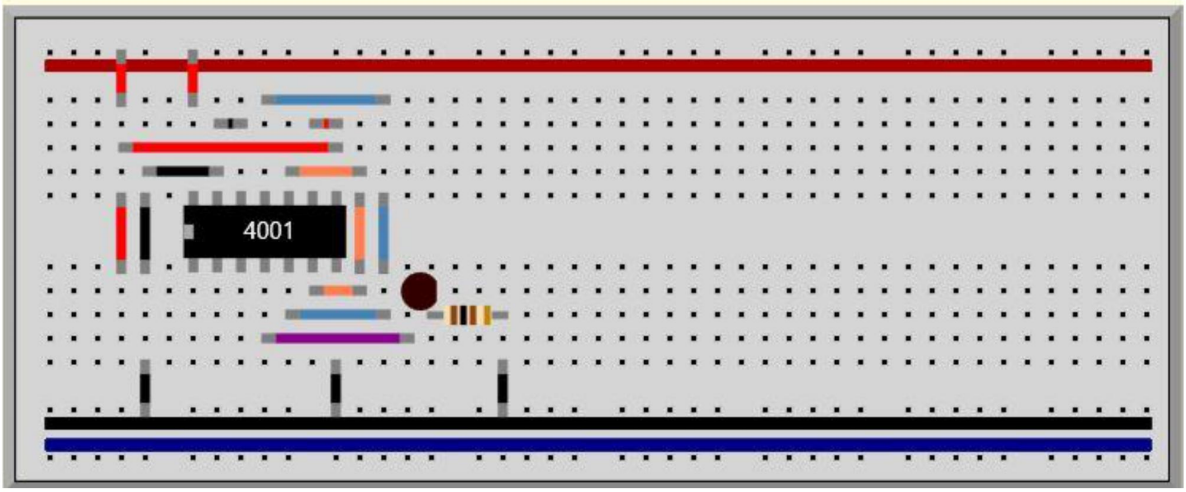
Input:1 1 Output:0



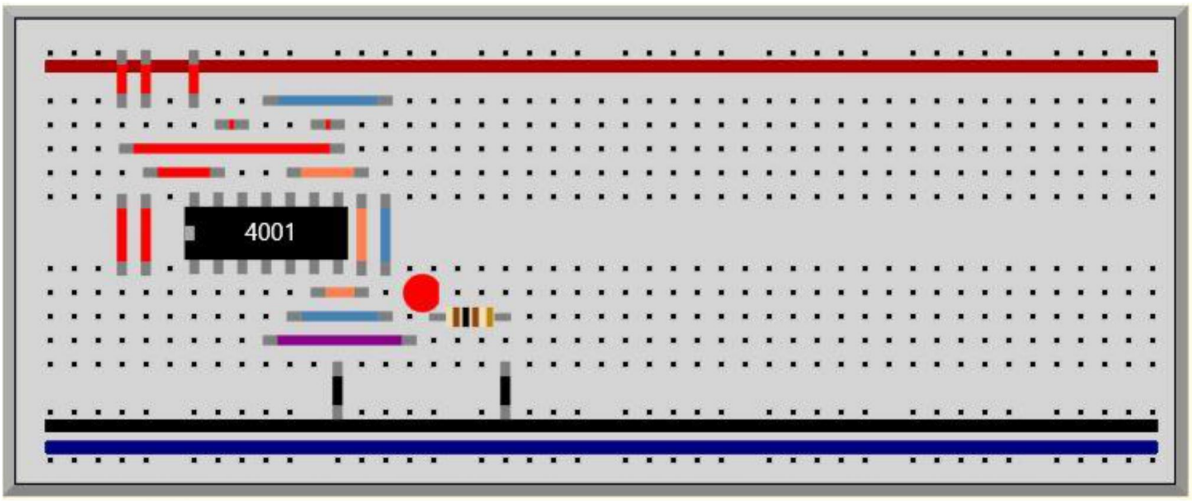
USING NOR GATE

AND

Input:1 0 Output:0

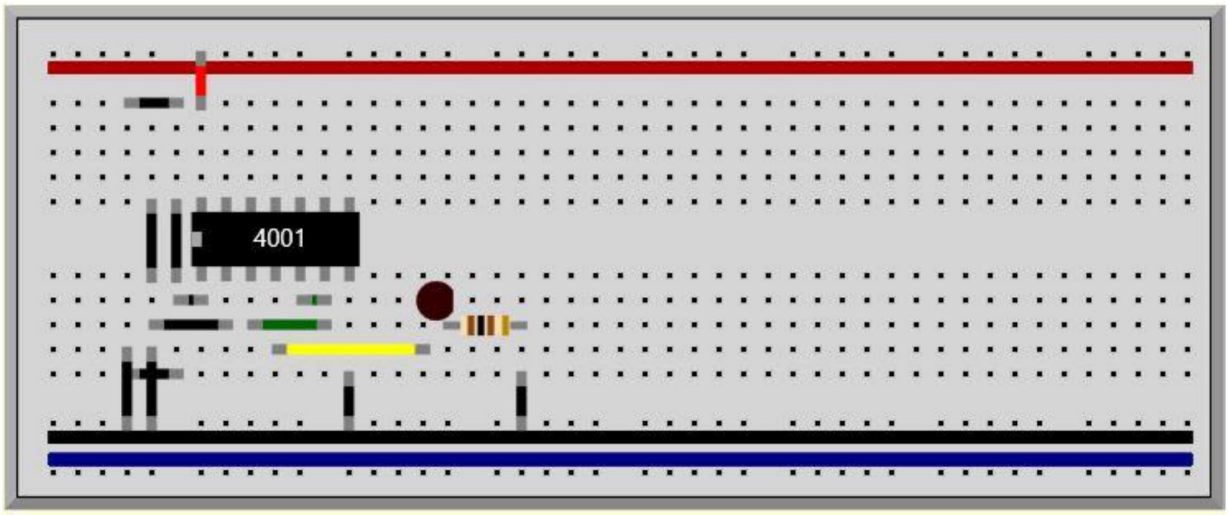


Input:1 1 Output:1

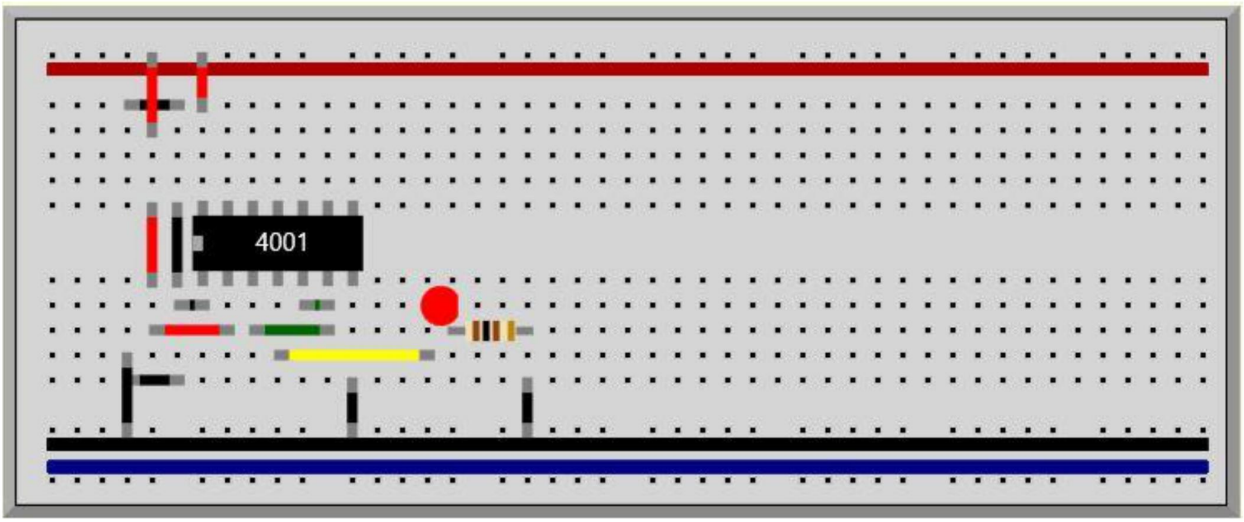


OR

Input:0 0 Output:0

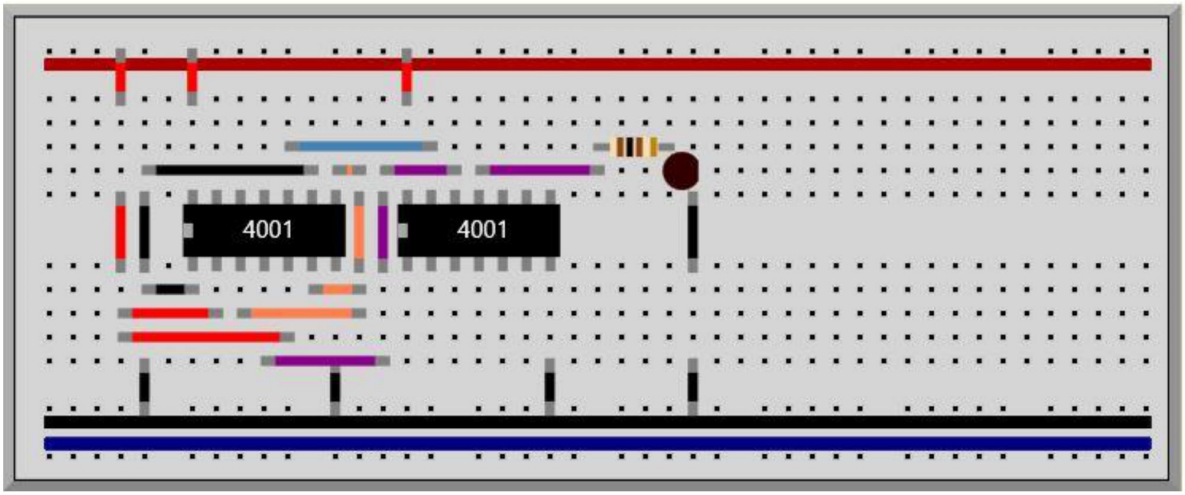


Input:1 0 Output:1

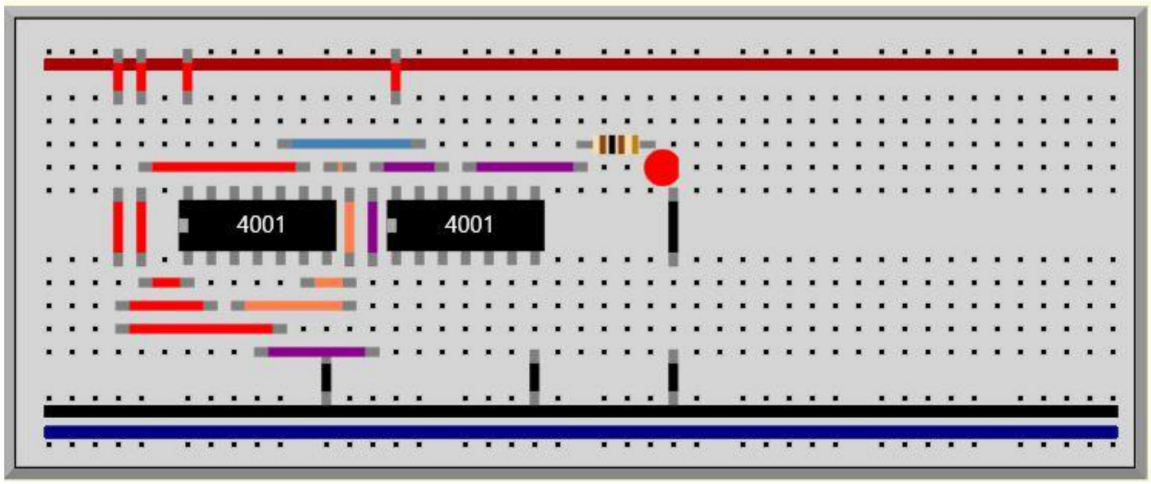


XNOR

Input:1 0 Output:1

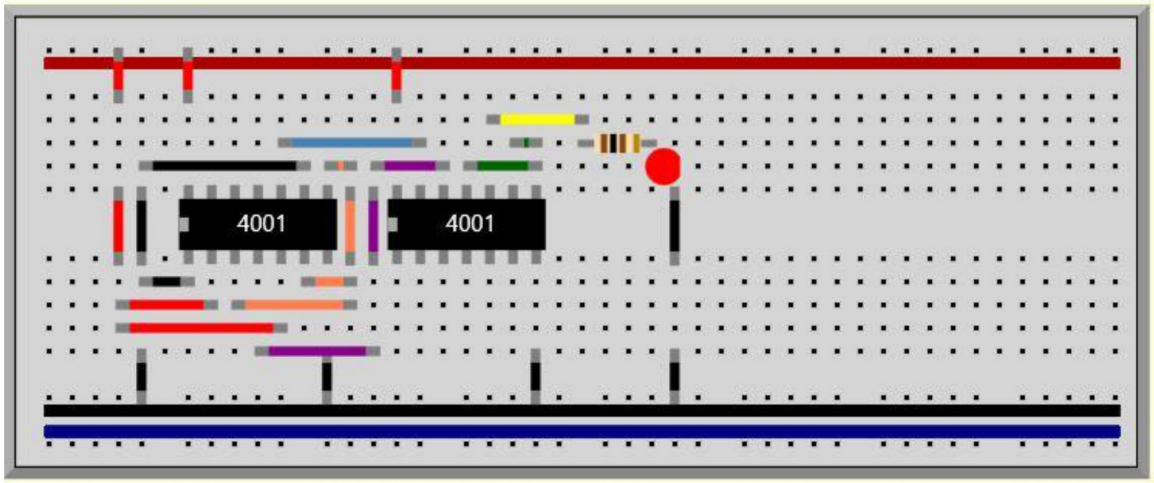


Input:1 1 Output:1



XOR

Input:1 0 Output:1



Input:1 1 Output:0