Indian Institute of Information Technology, Allahabad

ELECTRONICS AND COMMUNICATION ENGINEERING DEPARTMENT

Course Name: Fundamental of Electrical and Electronics

EXPERIMENT NO: 6

Objective: Realization of all logic gates through universal gates NAND and NOR.

Materials/ Component Required: NAND gate ICs 7400, NOR gate ICs IC 7402, wires

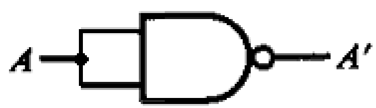
Theory:

(a) **NAND gate** is actually a combination of two logic gates: 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, output is always one. By using only NAND gates, we can realize all logic functions: AND, OR, NOT, X-OR, X-NOR, NOR. So this gate is also called universal gate.

(i) NAND gates as NOT gate

A NOT produces complement of the input. It can have only one input, tie the inputs of a NAND gate together. Now it will work as a NOT gate. Its output is

Y = (A.A)’
Y = (A)’

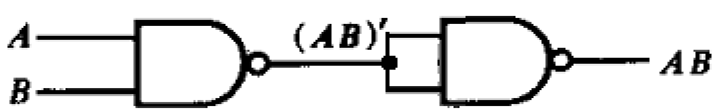


NOT (inverter)

(ii) 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.B)’)’
Y = (A.B)

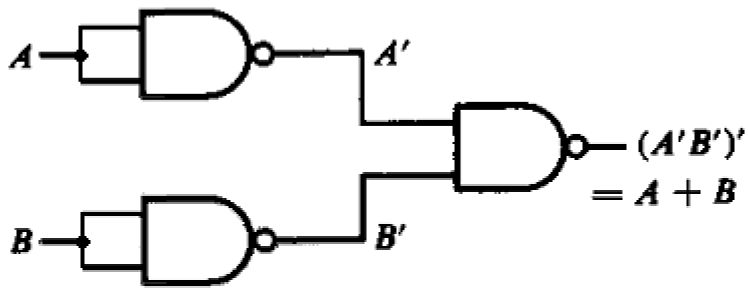


AND

(iii) NAND gates as OR gate

From DeMorgan’s theorems: (A.B)’ = A’ + B’
(A’.B’)’ = A’’ + B’’ = A + B

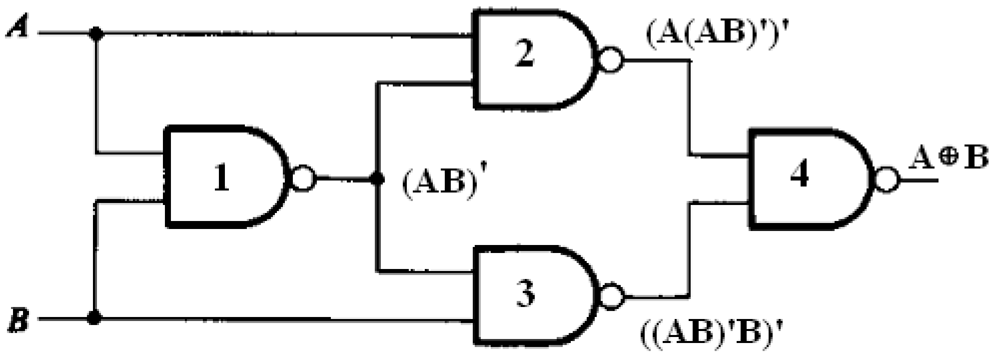
So, give the inverted inputs to a NAND gate, obtain OR operation at output.



OR

(iv) NAND gates as XOR gate

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



X-OR

Gate No.	Inputs	Output
1	A, B	(AB)'
2	A, (AB)'	(A (AB)')'
3	(AB)', B	(B (AB)')'
4	(A (AB)')', (B (AB)')'	A'B + AB'

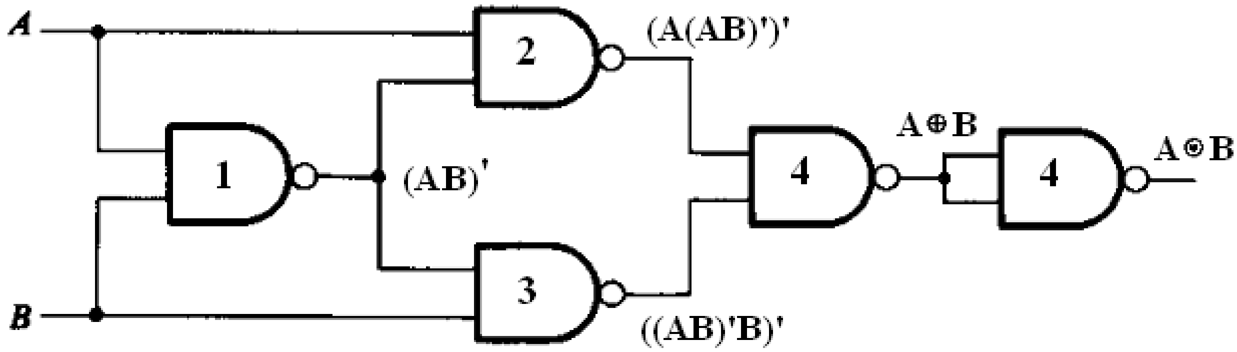
Now the output from gate no. 4 is the overall output of the configuration.

$$
\begin{aligned}
Y &= ((A\,(AB)')'\,(B\,(AB)')')' \\
&= (A(AB)')'' + (B(AB)')'' \\
&= (A(AB)') + (B(AB)') \\
&= (A(A' + B)') + (B(A' + B')) \\
&= (AA' + AB') + (BA' + BB') \\
&= (\ 0 + AB' + BA' + 0\ ) \\
&= AB' + BA' \\
Y &= AB' + A'B
\end{aligned}
$$

(v) NAND gates as X-NOR gate

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

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

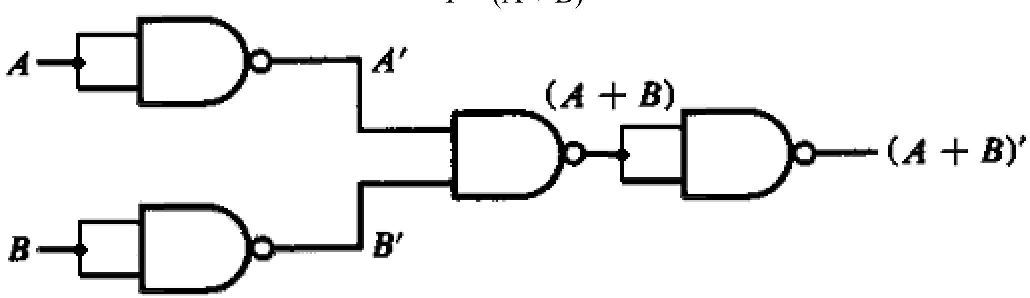


X-NOR

(vi) NAND gates as NOR gate

A NOR gate is an OR gate followed by NOT gate. So connect the output of OR gate to a NOT gate, overall output is that of a NOR gate.

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



NOR

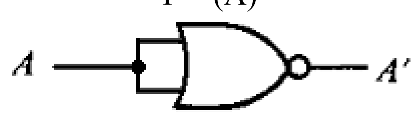
(b) **NOR gate** is actually a combination of two logic gates: OR gate followed by NOT gate. So its output is complement of the output of an OR gate. This gate can have minimum two inputs, output is always one. By using only NOR gates, we can realize all logic functions: AND, OR, NOT, X-OR, X-NOR, NAND.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

(i) NOR gates as NOT gate

A NOT produces complement of the input. It can have only one input, tie the inputs of a NOR gate together. Now it will work as a NOT gate. Its output is

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

$$Y = (A)'$$



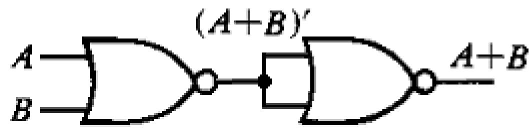
NOT

(ii) 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)



OR

(iii) NOR gates as AND gate

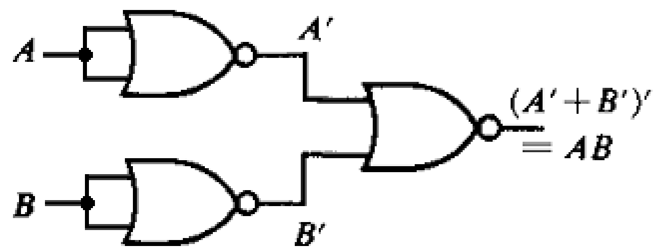
From DeMorgan’s theorems: (A+B)’ = A’B’

(A’+B’)’ = A’’B’’ = AB

Y = ((A+B)’)’

Y = (A+B)

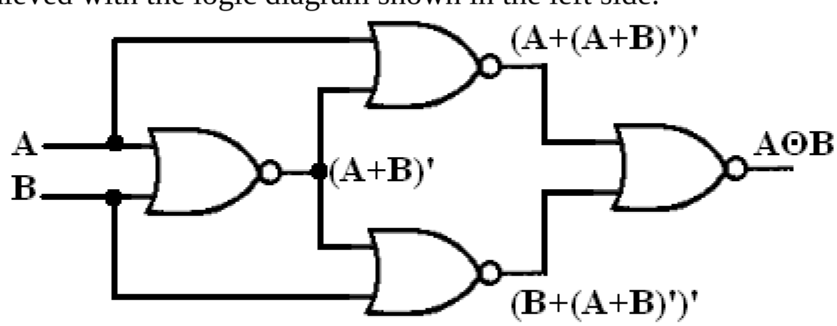
So, give the inverted inputs to a NOR gate, obtain AND operation at output.



AND

(iv) NOR gates as X-NOR gate

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



X-NOR

Gate No.	Inputs	Output
1	A, B	(A + B)’
2	A, (A + B)’	(A + (A+B)’)’
3	(A + B)’, B	(B + (A+B)’)’
4	(A + (A + B)’)’, (B + (A+B)’)’	AB + A’B’

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

Y = ((A + (A+B)’)’ (B +(A+B)’)’)’

= (A+(A+B)’)’’.(B+(A+B)’)’’

= (A+(A+B)’).(B+(A+B)’)

= (A+A’B’).(B+A’B’)

= (A + A’).(A + B’).(B+A’)(B+B’)

$= 1.(A+B').(B+A').1$

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

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

$= AB + AA' + B'B + B'A'$

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

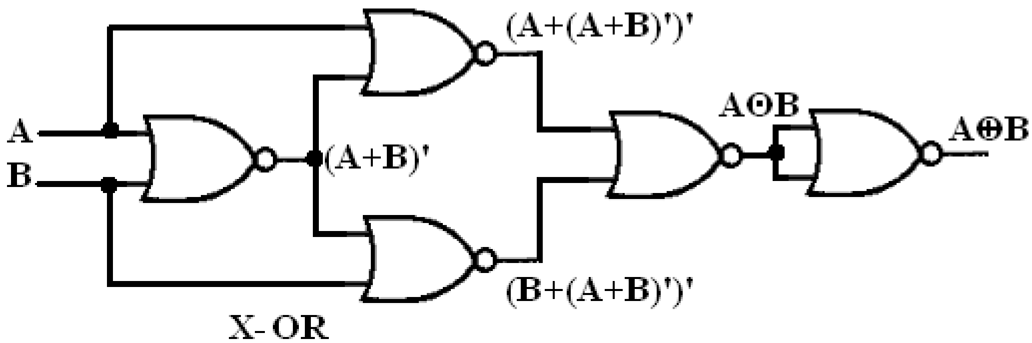
$= AB + B'A'$

$Y = AB + A'B'$

(v) NOR gates as X-NOR gate

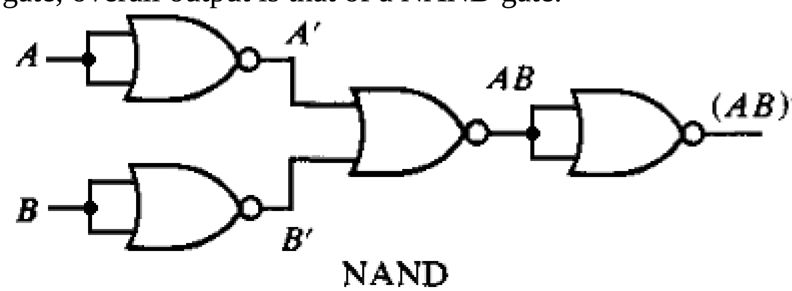
X-OR gate is actually X-NOR gate followed by NOT gate. So give the output of X-NOR gate to a NOT gate, overall output is that of an X-OR gate.

$Y = A'B + AB'$



(vi) NOR gates as NAND gate

A NAND gate is an AND gate followed by NOT gate. So connect the output of AND gate to a NOT gate, overall output is that of a NAND gate.



Result: Various truth tables for designing of all logic gates through universal gates have been verified.

Precautions:

a) Supply should not exceed 5V.
b) Connections should be tight and inspect.
c) Use L.E.D. with proper sign convention and check it before connecting in circuit.