Experiment No.2

universal gates –

Aim: - realization of logic gates using NAND and NOR gates.

Components: - IC 7400, 7402 – NOR

NAND

Apparatus: - Digital trainer kit, wires, probes, etc.

Theory:-

Universal gates: -

The Nand and Nor gates are called as universal gates, because it is possible to implement any Boolean expression with the help of only Nand or only Nor gates.

Hence a user can build any combinational circuit with the help of only Nand gates or only Nor gates.

The NAND & NOR gates are called as 'Universal gates'. Because it is possible to implement any Boolean expression with the help of only NAND or only NOR gate. We can construct AND, OR, NOT, X-OR & X-NOR gates.

The Boolean expression for NAND gate is,

$$X = \overline{AB}$$

The Boolean expression for NOR gate is,

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

This is a great advantage because a user will have to make a stock of only Nand or Nor gates.

All gates using Nand Gate:-

1) Not using Nand:-

   The Boolean expression for NOT gate is $A = \overline{A}$ Fig. shows the realization of a NOT gate using a two i/p NAND gate. As both i/p's are connected together we can write i/p A=B=A

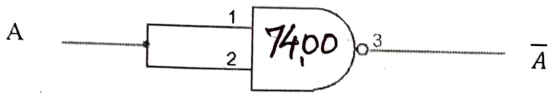
   So o/p is given as

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

$$Y = \overline{A.A} \qquad \because A = B$$

$$\text{But } A.A=A \qquad \because \text{by AND law}$$

$$Y = \overline{A}$$



2) AND using NAND:-

The Boolean expression for an AND gate is Y=A.B

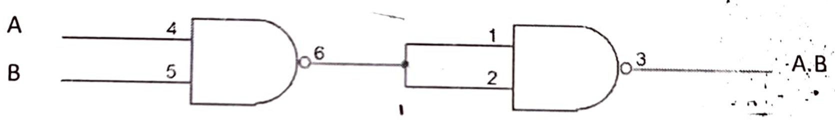
Taking double inversion,

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

$$\text{But } \overline{\overline{A}} = A$$

$$Y=A.B$$

This equation can be realized using only NAND gate as shown in fig.



3) OR using NAND:-

The Boolean expression for an OR gate is Y=A + B

Taking double inversion,

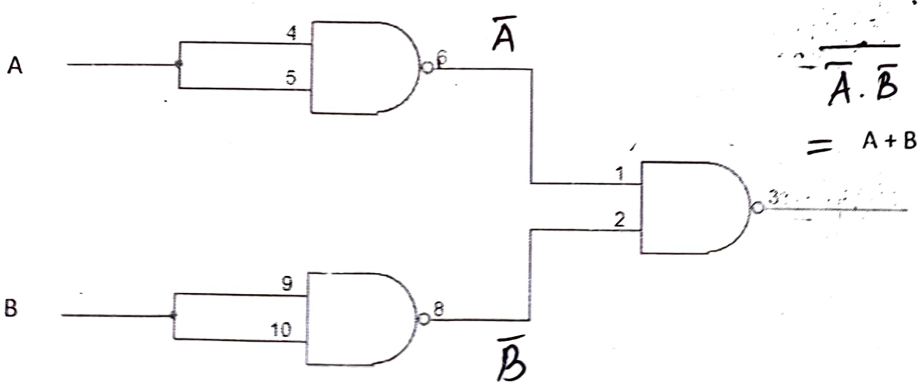
$$Y = \overline{\overline{A+B}}$$

But by DE-Morgan's theorem

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

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

This is required expression for OR gate



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

$= A+B = Y.$

4) NOR using NAND:-

The Boolean expression for an NOR gate is $Y = \overline{A + B}$

But by DE-Morgan's theorem

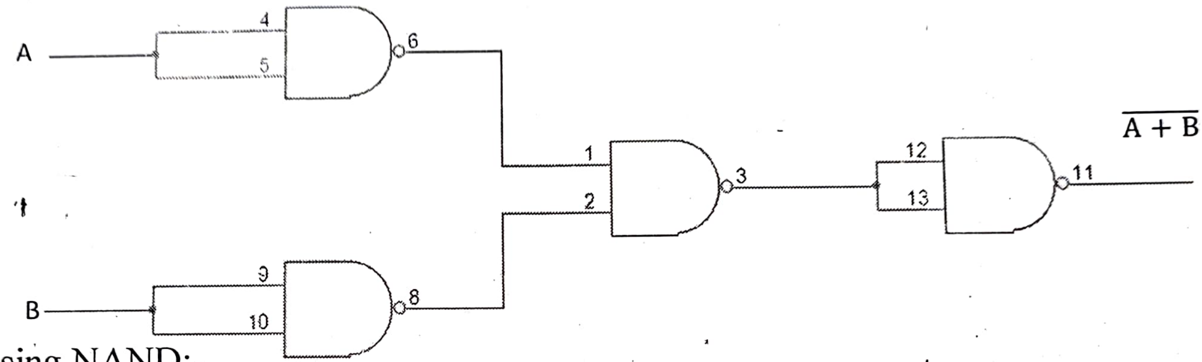
$$\overline{A + B} = \bar{A}.\bar{B}$$

$$Y = \bar{A}.\bar{B}$$

Taking double inversion,

$$Y = \overline{\overline{\bar{A}.\bar{B}}}$$

This is required expression for NOR gate



5) Ex-OR using NAND:-

The expression for Ex- OR gate is

$$Y = A \oplus B$$

$$Y = \bar{A}.B + A.\bar{B}$$

Taking double inversion

$$Y = \overline{\overline{\bar{A}.B + A.\bar{B}}}$$

Let $\bar{A}.B$ =X and $A.\bar{B}$ =Z

$$Y=\overline{\overline{X + Z}}$$

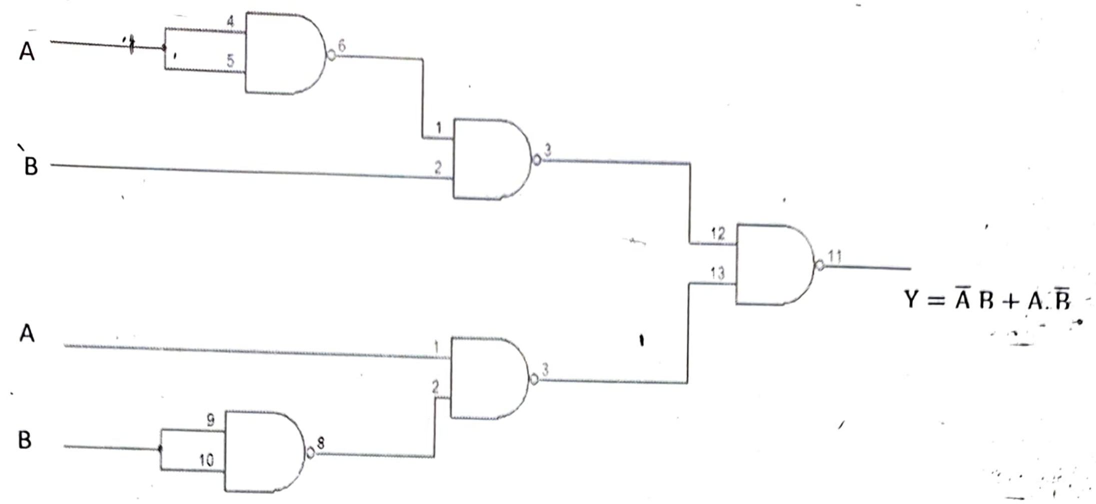
$$\text{using De} - \text{Morgan's theorem}$$

$$\overline{X + Z} = \bar{X}.\bar{Z}$$

$$Y = \overline{\overline{\bar{X}.\bar{Z}}}$$

$$Y = \overline{\overline{\overline{(\bar{A}B)}.\overline{(A.\bar{B})}}}$$

This is required expression for Ex-OR gate using NAND gate.



All gates using NOR Gate:-

1) Not using NOR:-

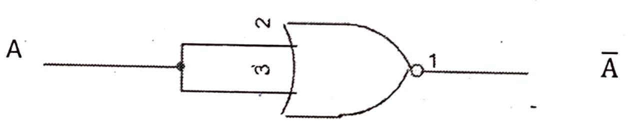
The Boolean expression for NOT gate is $A = \overline{A}$ Fig. shows the realization of a NOT gate using a two i/p NOR gate. As both i/p's are connected together we can write i/p A=B=A So o/p is given as

$$Y = \overline{A + B}$$

$$Y = \overline{A + A} \qquad \because A = B$$

$$\text{But } A+A=A \qquad \because \text{by OR law}$$

$$Y = \overline{A}$$



2) OR using NOR:-

The Boolean expression for an OR gate is Y=A+B

Taking double inversion,

$$Y = \overline{\overline{A + B}}$$

$$\text{But } \overline{\overline{A}} = A$$

$$Y=A+B$$

This equation can be realized using only NAND gate as shown in fig.

3) AND using NOR:-

The Boolean expression for an AND gate is Y=A.B

Taking double inversion,

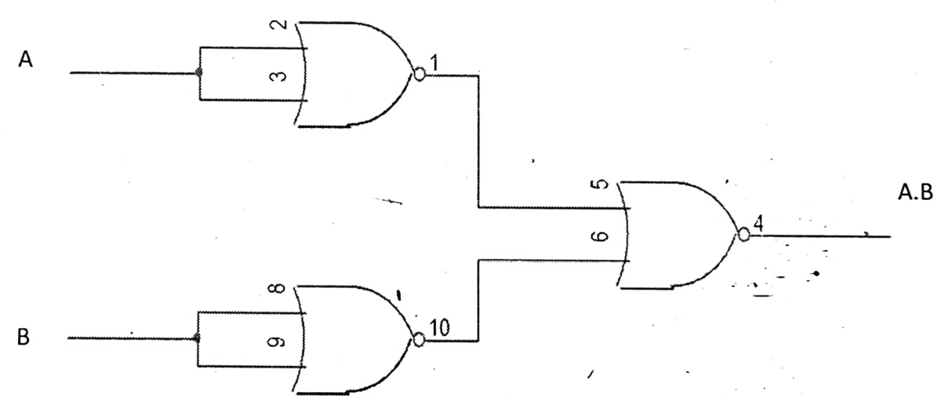
$$Y = \overline{\overline{A.B}}$$

But by DE-Morgan's theorem

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

$$Y = \overline{\overline{A} + \overline{B}}$$

This is required expression for AND gate



4) NAND using NOR:-

The Boolean expression for an NOR gate is $Y = \overline{A.B}$

But by DE-Morgan's theorem

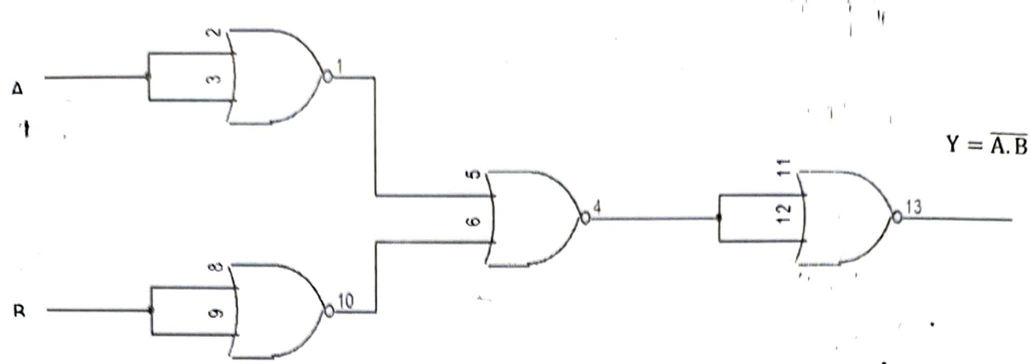
$$\overline{A.B} = \overline{A} + \overline{B}$$

$$Y = \overline{A} + \overline{B}$$

Taking double inversion,

$$Y = \overline{\overline{\overline{A} + \overline{B}}}$$

This is required expression for NAND gate



5)EX-OR using NOR:-

The expression for EX- OR gate is

$$Y = A \oplus B$$

$$Y = \bar{A}\,.\,B + A.\bar{B}$$

Taking double inversion

$$Y = \overline{\overline{\bar{A}\,.\,B + A.\bar{B}}}$$

Let $\bar{A}\,.\,B$ =X and $A.\bar{B}$ =Z

$$Y = \overline{\overline{X + Z}}$$

$$\text{using De} - \text{Morgan's theorem}$$

$$\overline{X + Z} = \bar{X}.\bar{Z}$$

$$Y = \overline{\bar{X}\,.\,\bar{Z}}$$

$$Y = \overline{\overline{(\bar{A}.B)}.\overline{(A.\bar{B})}}$$

But $\overline{\bar{A}.B} = A + \bar{B}$ and $\overline{A.\bar{B}} = \bar{A} + B$

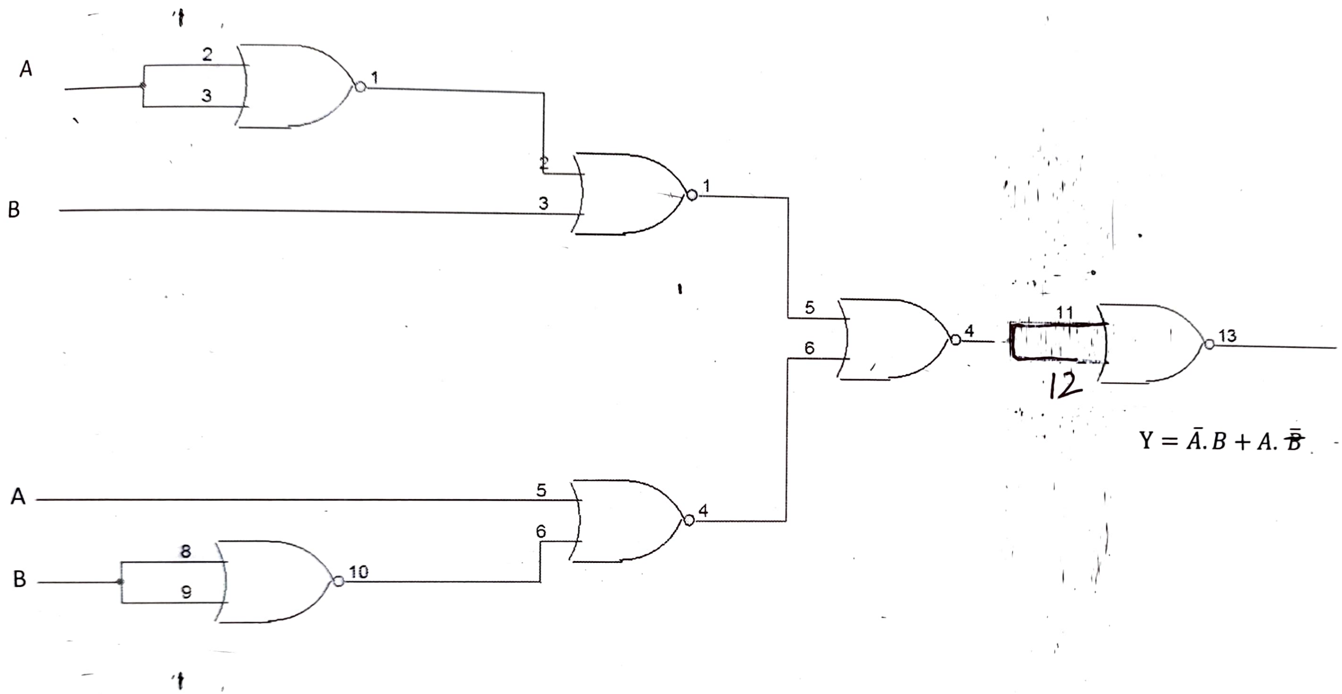
$$Y = \overline{(A + \bar{B}).(\bar{A} + B)}$$

$$Y = \overline{(A + \bar{B})} + \overline{(\bar{A} + B)}$$

Taking double inversion, we get

$$Y = \overline{\overline{\overline{(A + \bar{B})} + \overline{(\bar{A} + B)}}}$$

This is required expression for EX-OR gate using NOR gate.



$Y = \bar{A}.B + A.\bar{B}$

Conclusion:-

All the gates are realized using NAND and NOR gates and truth tables are verified.