Lecture 2

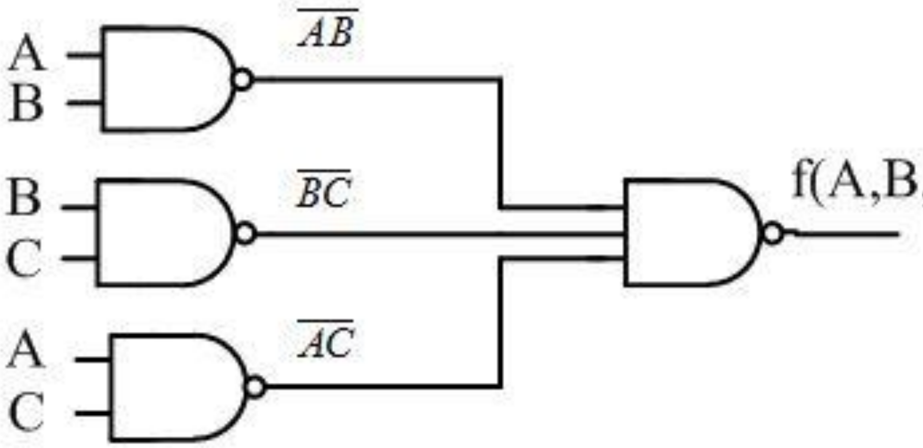
- Boolean function implementation using universal gates
- Boolean function simplification using algebraic method

Boolean function implementation using only NAND gates.

If the Boolean function is expressed in Sum of Products (SOP) form, NAND implementation is used.

Ex:- Let f(A,B,C)=AB+BC+AC implement using only NAND gates.

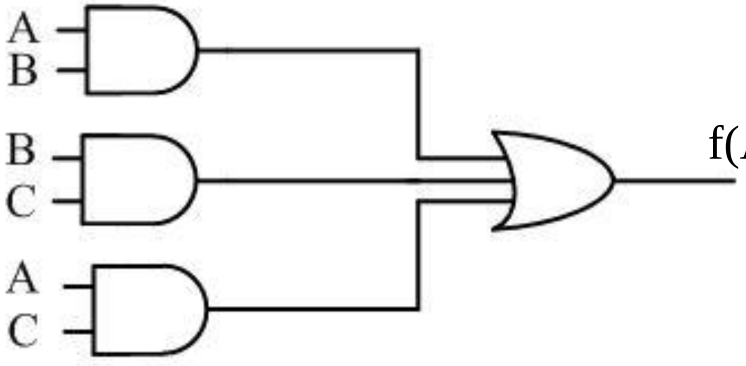
Sol:- $f(A,B,C) = \overline{\overline{AB + BC + AC}} = \overline{\overline{AB}.\overline{BC}.\overline{AC}}$



$f(A,B,C) = \overline{\overline{AB}.\overline{BC}.\overline{AC}}$

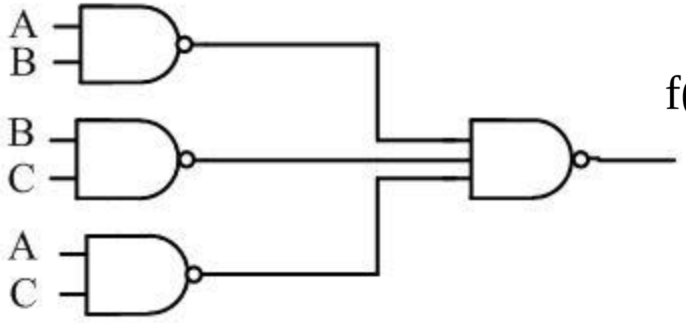
<u>Procedure to obtain NAND realization</u>:-

Step 1:-Draw two level AND-OR realization



f(A,B,C)=AB+BC+AC

Step 2:- Replace all the gates by NAND gates

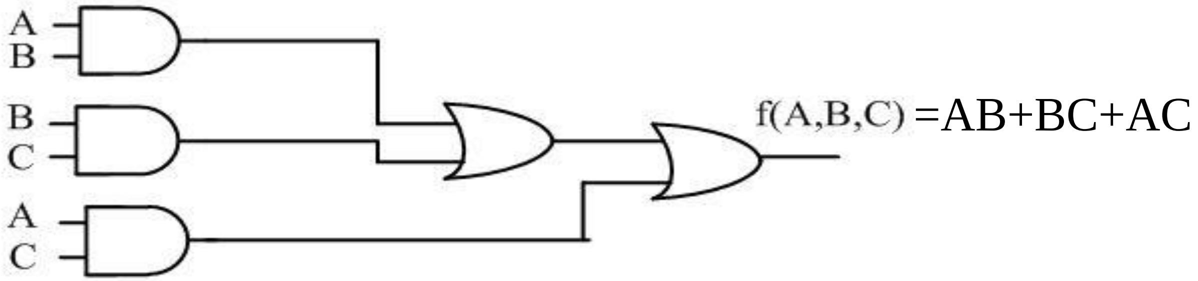


f(A,B,C)=AB+BC+AC

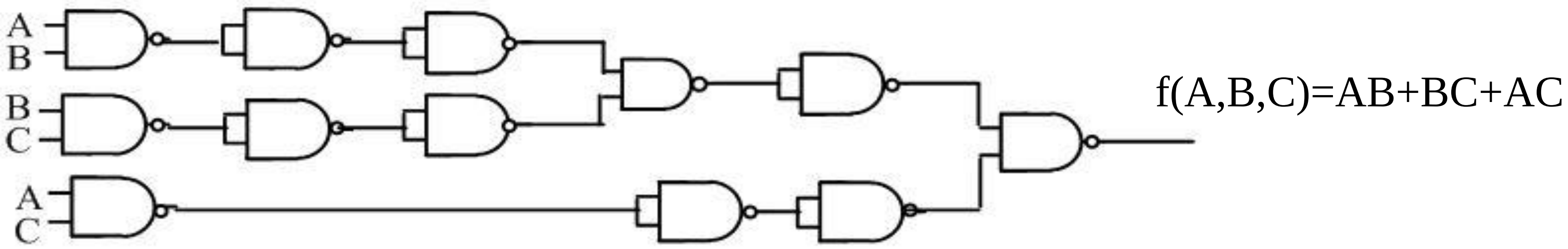
Implementation using only 2 input NAND gates

Procedure:-

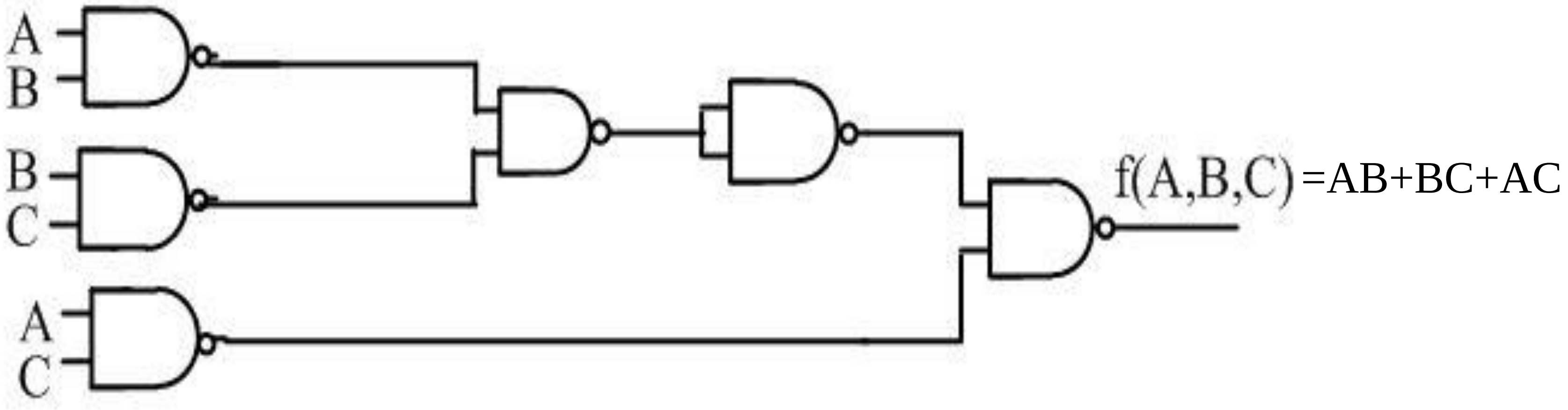
Step 1:-Implement the Boolean function using NOT, two input OR and AND gates



Step 2:-Replace every gate by its equivalent two input NAND realizations



Step 3:- Remove all the combinations of two series NOT gates and draw the simplified circuit.



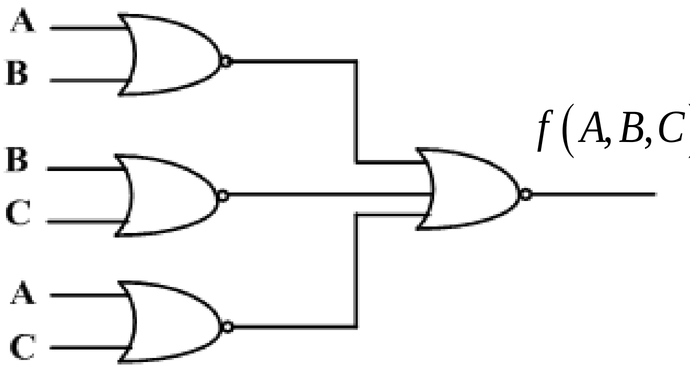
Boolean function implementation using only NOR gates

If the Boolean function is expressed in product of sum (PoS) form, NOR implementation is used.

Ex:- implement f(A,B,C)=(A+B)(B+C)(A+C) using only NOR gates

Sol:- $f(A,B,C)=\overline{\overline{(A+B)(B+C)(C+A)}}=\overline{\overline{(A+B)}+\overline{(B+C)}+\overline{(A+C)}}$

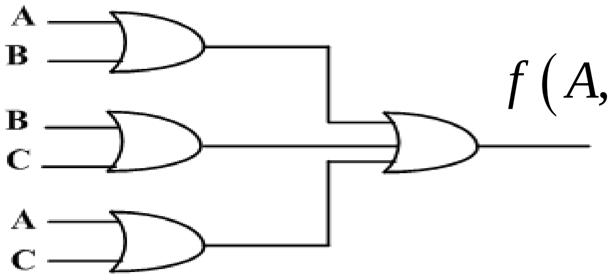
Implementation:-



$f(A,B,C)=\overline{\overline{(A+B)}+\overline{(B+C)}+\overline{(A+C)}}$

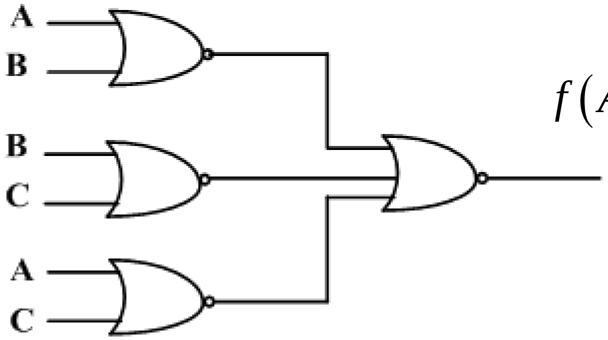
Procedure to obtain NOR realization

Step 1:- Derive two-level AND-OR realization



$$f\left(A,B,C\right)=(A+B)(B+C)(A+C)$$

Step 2:- Replace all the gates by NAND gates



$$f\left(A,B,C\right)=\overline{\overline{(A+B)}+\overline{(B+C)}+\overline{(A+C)}}$$

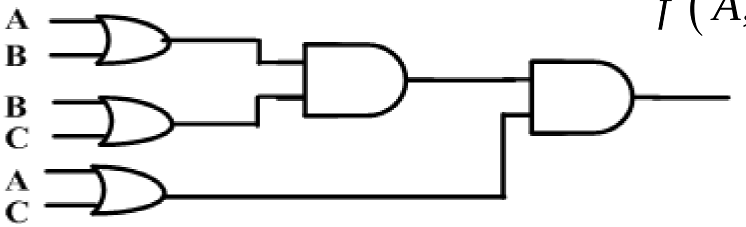
$$=(A+B)(B+C)(A+C)$$

Implementation using two input NOR gates

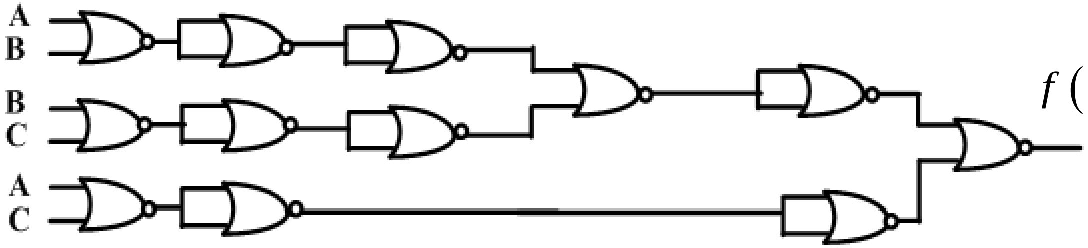
Procedure:-

Step 1:- Implementation given Boolean function using NOT,two input AND and two input OR gates

$$f\left(A,B,C\right)=(A+B)(B+C)(A+C)$$



Step 2:- Replace every gate by its equivalent two input NAND realization



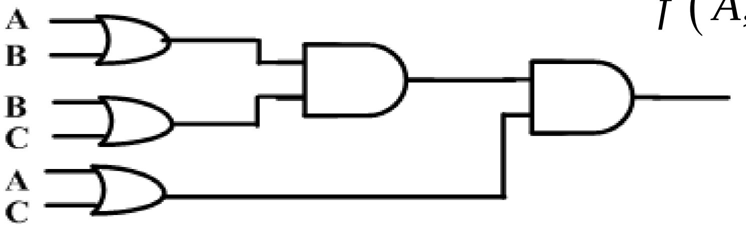
$f\left(A,B,C\right)$

Implementation using two input NOR gates

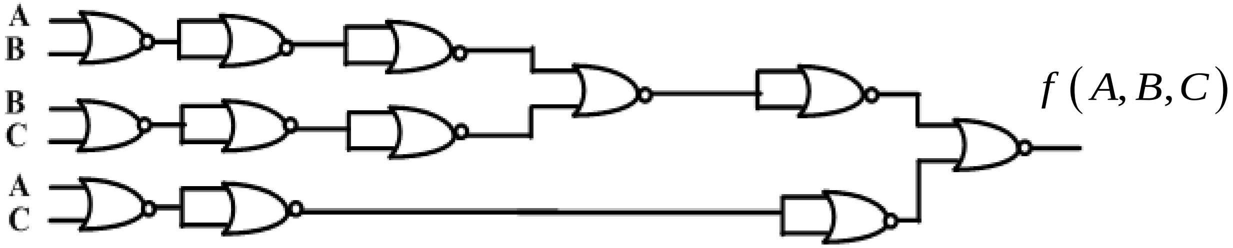
Procedure:-

Step 1:- Implementation given Boolean function using NOT,two input AND and two input OR gates

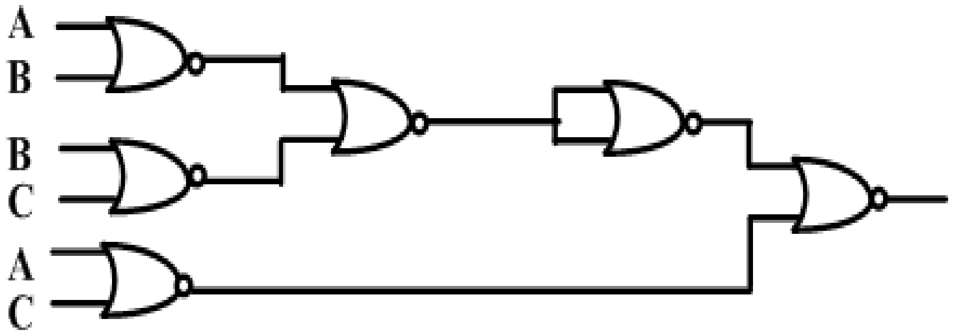
$$f\left(A,B,C\right) = (A+B)(B+C)(A+C)$$



Step 2:- Replace every gate by its equivalent two input NAND realization



Step 3:- Remove all the combinations of two series NOT gates and draw the simplified circuit

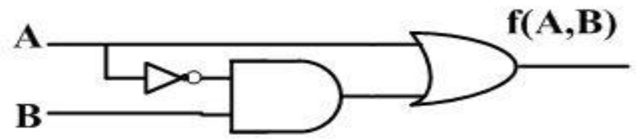


$$f\left(A,B,C\right) = (A+B)(B+C)(A+C)$$

Boolean function simplification using Algebraic method

- Boolean laws and theorems are used to simplify Boolean functions

Ex: $f(A,B)=A+\overline{A}B$



Direct implementation requires one two input AND gate ,one two input OR gate, one inverter

After simplification

$f(A,B)=A+\overline{A}B=(A+\overline{A})(A+B)=A+B$ → only one two input OR gate is required

- Simplify the following Boolean functions using Algebraic method

i. $f(A,B)=A+AB$

Sol:- $f(A,B)=A+AB$

$=A[1+B]=A.1$

$=A$

ii. $f(A,B,C) = ABC + A\overline{B} + AB\overline{C}$

Sol:- $f(A,B,C) = AB(C+\overline{C}) + A\overline{B} = AB + A\overline{B} = A(A+\overline{B}) = A$

iii. $f(A,B,C) = AB + \overline{A}C + BC$

$= AB + \overline{A}C + BC(A+\overline{A}) = AB + \overline{A}C + ABC + \overline{A}BC$

$= AB[1+C] + \overline{A}C\,[1+B] = AB + \overline{A}C$

iv. $f(A,B,C,D) = A\overline{B}D + A\overline{B}\,\overline{D}$

Sol:- $f(A,B,C,D) = A\overline{B}D + A\overline{B}\,\overline{D} = A\overline{B}(D+\overline{D}) = A\overline{B}$

v. $f(A,B,C) = A\overline{C} + AB\overline{C}$

Sol:- $f(A,B,C) = A\overline{C}[1+B] = A\overline{C}$

vi. $f(A,B,C,D) = \overline{A}\,\overline{B}\,C\,\overline{D} + \overline{A}\,\overline{B}\,\overline{C}\,\overline{D}$

Sol:- $f(A,B,C,D) = \overline{A}\,\overline{B}\,\overline{D}[C+\overline{C}] = \overline{A}\,\overline{B}\,\overline{D}$

vii. $f(A,B,C) = (\overline{A}+B)(A+B+C)\overline{C}$

Sol. $f(A,B,C) = (\overline{A}+B)(A+B)\overline{C} = (B + A\overline{A})\overline{C} = B\overline{C}$

So, simplification using algebraic method is difficult task in case of complex Boolean expression. Hence, K-map technique is used.