Name - D. Udari Nilushika Silva
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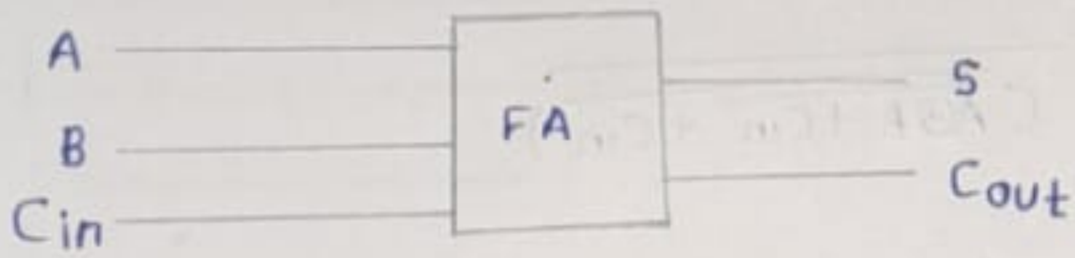
Design of a full adder using NOR gates.

There are three inputs [A, B (binary bits), C_{in} (carry in bit)] and two outputs [Sum (S), Carry out bit (C_{out})].



Truth table :-

Inputs			Outputs	
A	B	Cin	S	Cout
0	0	0	0	0
0	0	1	1	0
0	1	0	1	0
0	1	1	0	1
1	0	0	1	0
1	0	1	0	1
1	1	0	0	1
1	1	1	1	1

Logical expressin for sum,

$$S = \bar{A}\bar{B}C + \bar{A}B\bar{C}_{in} + A\bar{B}\bar{C}_{in} + ABC_{in}$$
$$= C_{in}(\bar{A}\bar{B} + AB) + \bar{C}_{in}(\bar{A}B + A\bar{B})$$
$$= (A \odot B)\, C_{in} + (A \oplus B)\, \bar{C}_{in}$$
$$= (\overline{A \oplus B}).\, C_{in} + (A \oplus B)\, \bar{C}$$
$$= \underline{\underline{A \oplus B \oplus C_{in}}}$$

Logical expression for Carry out,

$$C_{out} = \bar{A}BC_{in} + A\bar{B}C_{in} + AB\bar{C}_{in} + ABC_{in}$$
$$= BC_{in}\underbrace{(\bar{A} + A)} + A\bar{B}C_{in} + AB\bar{C}_{in}$$
$$= BC_{in} + A\bar{B}C_{in} + AB\bar{C}_{in} \quad (A + \bar{A}) = 1$$
$$= C_{in}(B + A\bar{B}) + AB\bar{C}_{in}$$
$$= C_{in}(A + B) + AB\bar{C}_{in} \quad (\bar{A}B + A = B + A)$$
$$= C_{in}A + C_{in}B + AB\bar{C}_{in}$$
$$= C_{in}B + A(B\bar{C}_{in} + C_{in})$$
$$= C_{in}B + A(B + C) \quad (B\bar{C}_{in} + C_{in} = B + C_{in})$$
$$= \underline{\underline{C_{in}B + AB + AC}}$$

Simplify for NOR gates.

$S = A \oplus B \oplus C_{in}$

$= A\oplus B \cdot \bar{C}_{in} + \overline{A \oplus B} \cdot C_{in}$

$= (A\oplus B \cdot \bar{C}_{in} + \overline{A\oplus B})(A\oplus B \bar{C}_{in} + C_{in})$

$= (\overline{\overline{A\oplus B} + C_{in}} + \overline{A\oplus B})(\overline{\overline{A\oplus B} + C_{in}} + C_{in})$

$= \overline{\overline{(\overline{\overline{A\oplus B} + C_{in}} + \overline{A\oplus B})} + \overline{(\overline{\overline{A\oplus B} + C_{in}} + C_{in})}}$

$\because \overline{A\oplus B} = A \odot B$

$= \overline{(\overline{A\odot B + C_{in}} + A\odot B) + (\overline{A\odot B + C_{in}} + C_{in})}$

$C_{out} = AB + BC_{in} + AC_{in}$

$= AB + AB + AC_{in} + BC_{in}$

$= AB + A\bar{A}\bar{B} + AC_{in} + BAB + B\bar{A}\bar{B} + BC_{in}$

$= (A+B)(AB + \bar{A}\bar{B} + C_{in})$

$= (A+B)((A\odot B) + C_{in})$

$= (\overline{\overline{A+B}})(\overline{\overline{A\odot B + C_{in}}})$

$= \overline{\overline{A+B} + \overline{(A\odot B) + C_{in}}}$

Logic diagram