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COMBINATIONAL SWITCHING CIRCUIT

There are two types of logic circuit.
i) combinational circuit
2) sequential circuit.

1) combinational circuit —

A logic device whose output value at any given instant, depends only upon the input value at that time

2. Sequential circuit -

A sequence circuit consists of combinational circuit as well as memory elements (used to store certain circuit states). output depend both the current input values and previous input value. (kept in the storage element)

- combinational circuits are those logic circuits whose operations can be completely described by a truth table/ Boolean expression.

- A combinational circuit is realized using AND, OR and NOT gets (or NAND or NOR gates).

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- Examples of combinational circuit are address, encoders, decoders, multiplexers/ Selectors, subtractors etc.

- A combinational circuit consists of logic gates whose output at any time are determined by combining the value of input.

- for n input variable there are 2^n possible binary input combination.

  $n=3 \quad 2^n = 2^3 = 8$

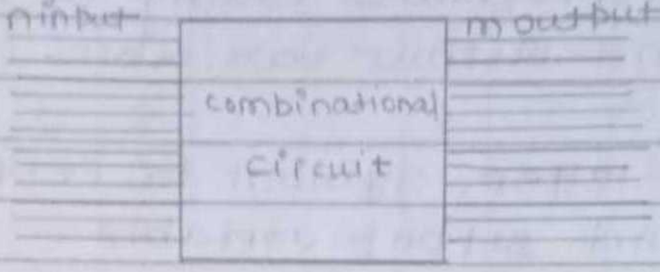
  $n=4 \quad 2^n = 2^4 = 16$ etc.

- For each binary combination of the input variable, there is one possible binary value on each output.

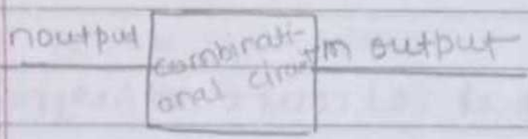
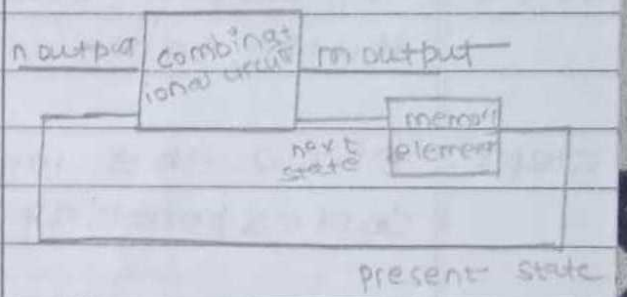
CONCLUSION - Hence combinational circuit described by

- A truth table that lists the output variable for each combination of the input variable.

- m Boolean function one for each output variable.



combinational circuit vs sequential circuit

Combinational circuit	Sequential circuit
	
combinational circuit are may less. Thus, the output value depend on the current input value	sequential circuit consist of combinational circuits as memory element. Thus output value depend upon current input value and previous input value.

combinational circuit design procedure

step1. state the problem.

step 2. find out the input and output variable

Step-3. use an appropriate coding to represent input and output variable.

Step-4. Assign a letter, symbol to represent input and output variable.

Step 5. obtain a truth table using the word statement of the problem.

Step 6. Represent each output variable in truth table.

Step 7. Draw the logical circuit diagram corresponding to the Boolean expression.

If A, B, C, D be the input variable and S_1, S_2, S_3 be the output variable.

$S_1 = D \cdot (\overline{A} + \overline{B} + \overline{C})$

$S_2 = \overline{A}$

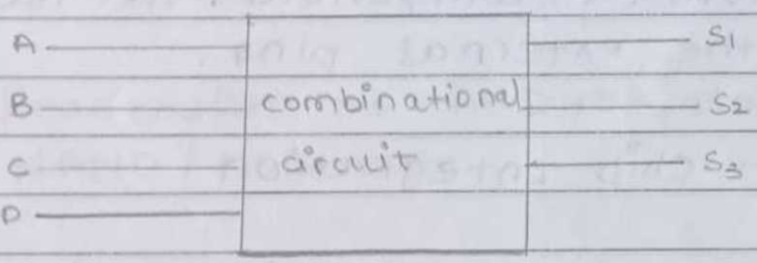
$S_3 = \overline{B}$

Truth Table.

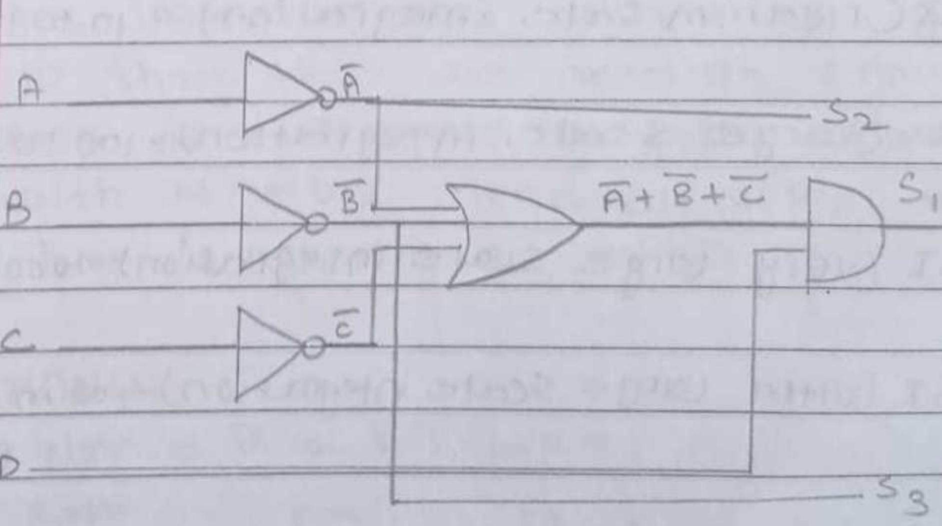
Input								Output		
A	B	C	D	$\overline{A}$	$\overline{B}$	$\overline{C}$	$\overline{A}+\overline{B}+\overline{C}$	S_1	S_2	S_3
0	0	0	0	1	1	1	1	0	1	1
0	0	0	1	1	1	1	1	1	1	1
0	0	1	0	1	1	0	1	0	01	0
0	0	1	1	1	1	0	1	1	1	0
0	1	0	0	1	0	1	1	0	0	1
0	1	0	1	1	0	1	1	1	0	1

0	1	1	0	1	0	0	1	0	0	0
0	1	1	1	1	0	0	1	1	0	0
1	0	0	0	0	1	1	1	0	1	1
1	0	0	1	0	1	1	1	1	1	1
1	0	1	0	0	1	0	1	0	1	0
1	0	1	1	0	1	0	1	1	1	0
1	1	0	0	0	0	1	1	0	0	1
1	1	0	1	0	0	1	1	1	0	1
1	1	1	0	0	0	0	0	0	0	0
1	1	1	1	0	0	0	0	0	0	0

Block diagram.



logical circuit



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Integrated circuit

1. Integrated circuit informally a chip (is a semiconductor crystal most often silicon) containing the electronic components for the digital gates.

2. The storage element which are interconnected on the chip.

3. The circuit is said to be integrated because a user does not have access to individual component. He has access only to the external pins.

Level of chip Integration

SSI (small scale integration) - Fewer than 10 gates.

MSI (Medium scale integration) – 10 to 100 gates.

LSI (Large scale integration) - 100 to 1000 gates

VLSI (very large scale integration) - 1000 to 1 million

ULSI (ultra large scale integration) - 100 million of gates.

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Advantages of IC

1. Reduction in cost of indivisual circuit.

2. Reduction in power consumption.

3. Reduction in size of the circuit.

4. Reduction in external wiring.

5. Increase the speed of operations.

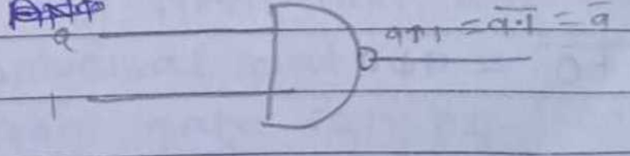
6. Increase reliability.

Realization of AND, OR, NOT, with NAND / NOR Gate

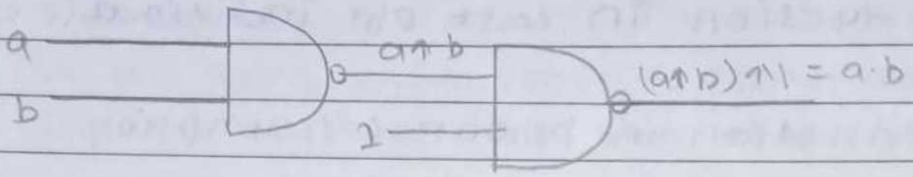
The NAND and NOR gate are universal gate as any boolean expression may be implemented with these gates. To show this we need to show that AND, OR, NOT gate may be implemented with NAND's alone or NOR's alone. That is shown as follow.

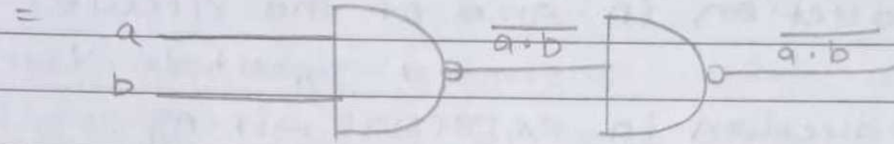
NAND.

$NOT = \overline{a} = \overline{a \cdot 1} = a \uparrow 1$



AND $= a\cdot b = \overline{a\cdot b} = \overline{a\uparrow b} = (\overline{a\uparrow b})\cdot 1 = (a\uparrow b)\uparrow 1$

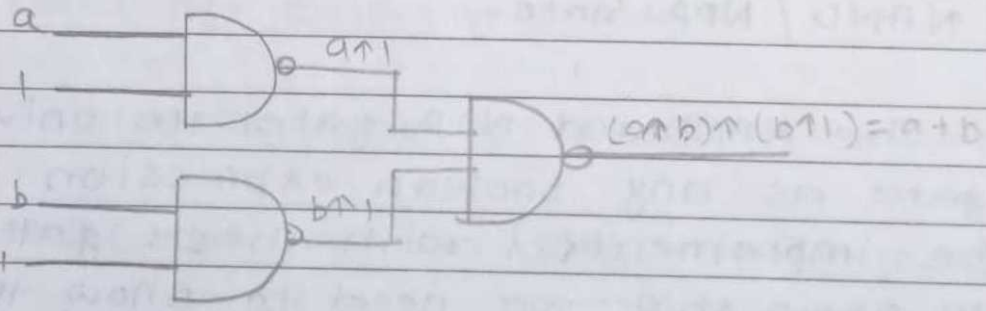




OR $= a+b = \overline{a+b} = \overline{\bar{a}\cdot\bar{b}} = \overline{\overline{a\cdot 1}\cdot\overline{b\cdot 1}}$

according to De Morgan's law

$= \overline{(a\uparrow 1)\cdot(b\uparrow 1)} = (a\uparrow 1)\uparrow(b\uparrow 1)$



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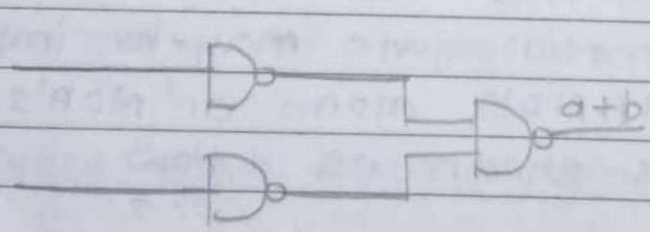
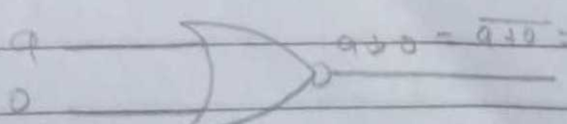


Realization of AND, OR, NOT with NOR Gate

NOT $= \bar{a} = \overline{a+0} = a\downarrow 0$



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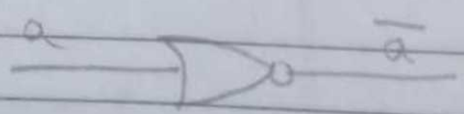
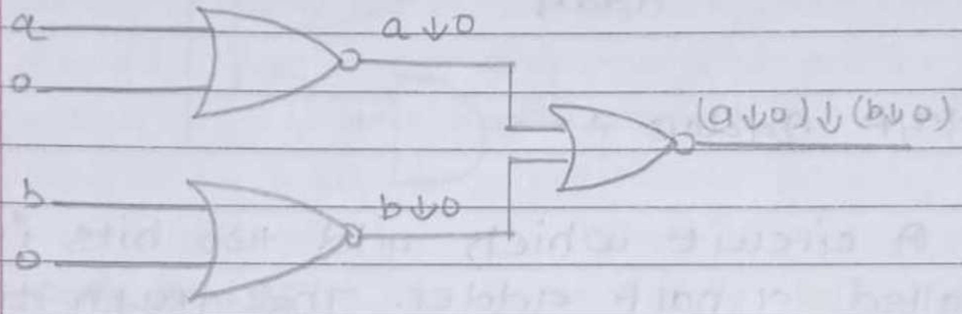


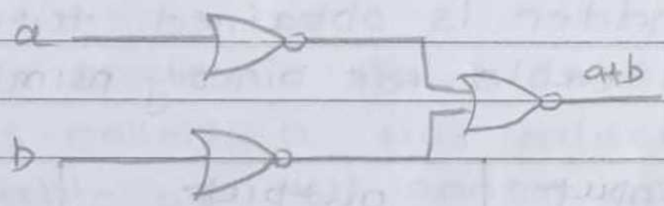
AND =

$$a+b = \overline{a+b} = \overline{a \downarrow b} = \overline{\overline{(a\downarrow 0)} + \overline{(b\downarrow 0)}}$$

$$= \overline{(a\downarrow 0) \downarrow (b\downarrow 0)}$$

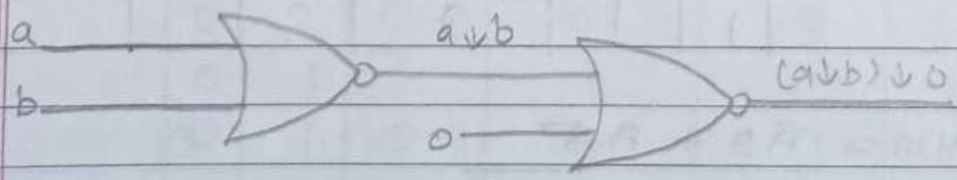
$$= (a\downarrow 0) \downarrow (b\downarrow 0)$$

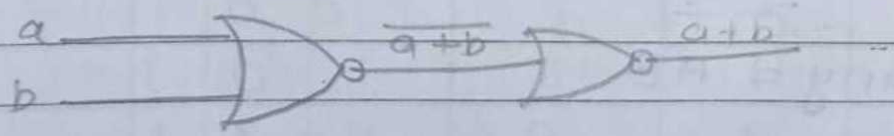




$$OR = a+b = \overline{\overline{a+b}} = \overline{a\downarrow b} = \overline{(a\downarrow b)+0}$$

$$= (a\downarrow b)\downarrow 0$$





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Why NAND and NOR gate is called universal gate.

Any gate can be realized with the help of NOR / NAND

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Some common combinational circuit used in digital system

- Half adder
- full adder.

Half Adder :—

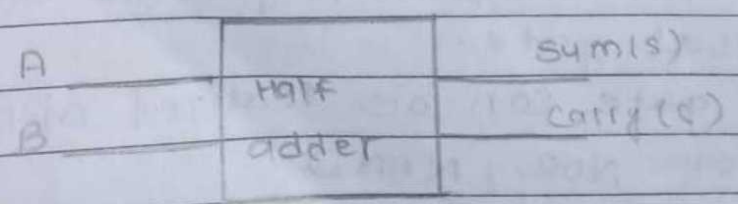
A circuit which add two bits is called a half adder. The truth table of half adder is obtained from the additional table for binary number given in.

Input		output	
A	B	sum(s)	carry (c)
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

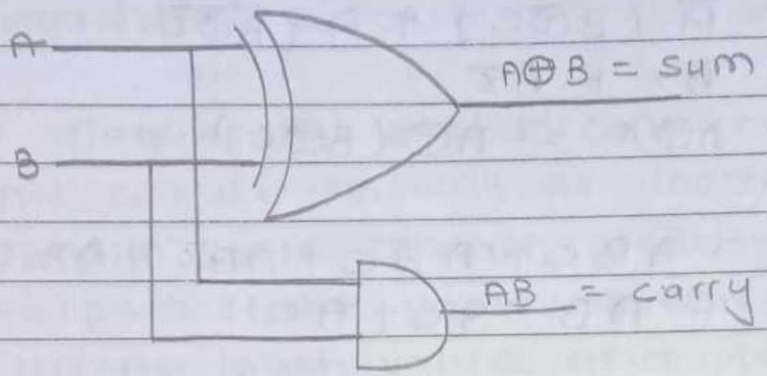
$$\text{sum} = \bar{A}B + A\bar{B}$$
$$= A \oplus B$$

$$\text{carry} = AB$$

Block diagram



Logical circuit.



Full Adder:-

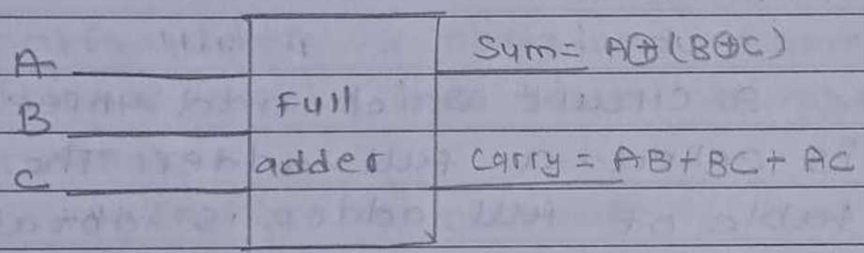
A circuit which add three digit bit is called a full adder. The truth table of full adder is obtained from the additional table for binary number given in.

A	B	C	sum	carry
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

$$Sum = \bar{A}\bar{B}C + \bar{A}B\bar{C} + A\bar{B}\bar{C} + ABC$$
$$= \bar{A}(\bar{B}C + B\bar{C}) + A(\bar{B}\bar{C} + BC)$$
$$= \bar{A}(B \oplus C) + A(\overline{B \oplus C})$$
$$= \bar{A}x + A\bar{x}$$
$$= A \oplus x = A \oplus (B \oplus C)$$

$$Carry = \bar{A}BC + A\bar{B}C + AB\bar{C} + ABC$$
$$= AB + BC + AC$$

Block diagram.



Logical circuit