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SUBJECT- DIGITAL TECHNIQUES.

BRANCH - COMPUTER SCIENCE ENGINEERING.

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SEMI CONDUCTOR'S BASICS

CONDUCTOR

Conductors are materials that allow the flow of electric current or heat due to their free-moving electrons. They typically have low resistance and high conductivity. Common examples include metals like copper, aluminum and gold. In electrical applications, conductors are used in wiring and components to facilitate the transfer of electricity. In thermal applications, they help in transferring heat efficiency.

INSULATORS

An insulator is a material that resists the flow of electric current or heat. Insulators are characterized by their high electrical resistance and low thermal conductivity. Common examples include rubber, glass, wood and plastic, etc.

In electrical applications, insulators are used to protect conductors, preventing unwanted current flow and ensuring safety.

SEMICONDUCTORS

A semiconductor is a material with electrical conductivity between that of conductors and insulators. It's conductivity can be modified through the introduction of impurities (dopping) or by changing

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temperature, making it essential for electro-nic devices.

- Applications of semiconductors :-

- Transistors :- essential components in amplifiers and digital circuits.

- Diodes :- Used in rectifiers and signal processing

- Photovoltaic cells :- Convert sunlight into electricity

- LEDs :- Light Emitting diodes used for lighting and displays.

ENERGY BAND

In an isolated atom, the electrons in each orbit possess definite energy. But, in case of solids, the energy level of the outermost orbit electrons is affected by the neighbouring atoms.

When two isolated charges are brought close to each other, the electrons in the outermost orbit experience an attractive force from other nearest or neighbouring atomic nucleus. Due to this reason, the energies of the electrons will not be at the same level, the energy levels of electrons are changed to a value which is higher than that of the original energy level of electron.

The electrons in the same orbit exhibit different energy levels. The grouping of these different energy levels is known as energy band.

- Classification of energy Bands.

1) Valence Band :- The electrone in the outermost shell are known as valence

electrones. These valence electrons contain the series of energy levels and from an energy band known as the valence band. The valence band has the highest occupied energy.

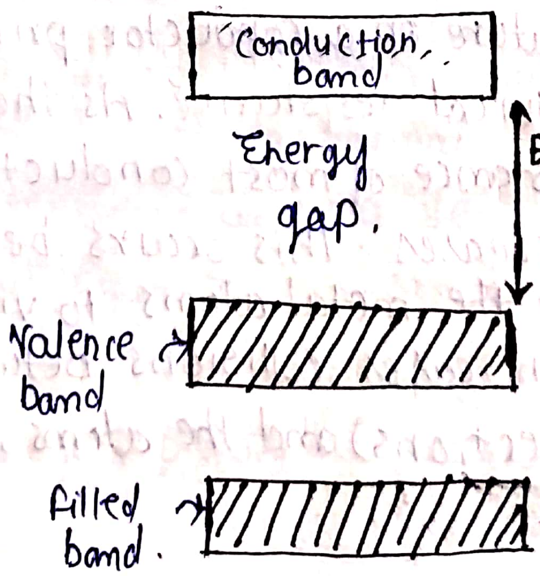
2) Conduction Band :- The valence electrons are not tightly held to the nucleus, due to ~~th~~ which a few of these valence electrons leave the outermost orbit even in room temperature and become free electrons. The free electrons conduct current in conductors and are therefore known as conduction electrons. The conduction band is one that contains conduction electrons and has the lowest occupied energy levels.

3) Forbidden Energy Gap :-

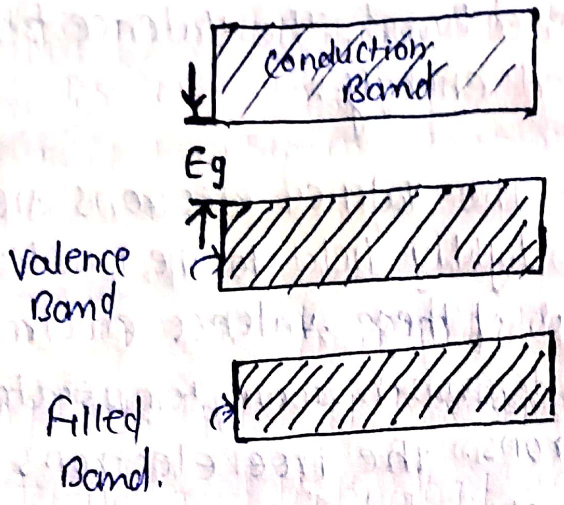
The gap between the valence band and the conduction band is reffered to as the forbidden gap. As the name suggests, the forbidden gap doesn't have any energy and no electrons stay in this band.

—: ENERGY BAND IN MATERIALS :-

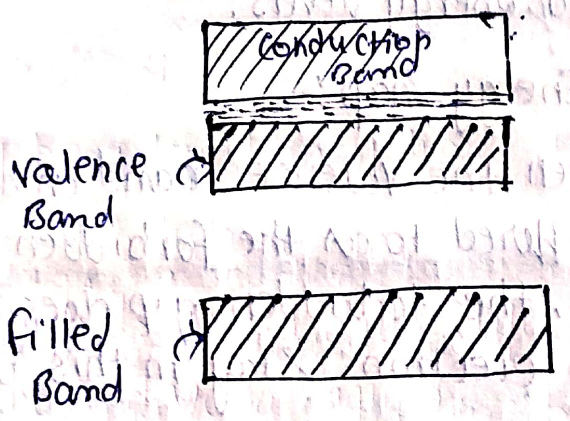
(i) In INSULATORS



(2) IN SEMICONDUCTORS.



(3) IN CONDUCTORS (METALS)



* EFFECT OF TEMPERATURE ON CONDUCTORS, SEMICONDUCTORS AND INSULATORS.

(i) ON CONDUCTORS

The effect of temperature on a conductor primarily influences its electrical resistance. As the temprature increases, the resistance of most conductors, such as metals also increases. This occurs because higher temperatures cause the metal atoms to vibrate more vigorously, which increases collisions between the charge carriers (electrons) and the atoms, impeding their flow.

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(ii) ON SEMICONDUCTORS

The effect of temprature on semiconductors is quite different from that in conductors. Here are the key Points.

(i) Intrinstic Semiconductors:- As temperature increases, the thermal energy provides electrons enough energy to move from the valence band to conduction band; thereby increasing the number of charge carriers. This leads to a decrease in resistance and an increase in conductivity.

(ii) Extrinsic Semiconductors:- For doped semiconductors (n-type or p-type) increasing temperature can also lead to more charge carriers being released from dopant atoms. This enhances conductivity further.

(iii) Energy Bandgap:- The bandgap of a semiconductor generally decreases with increasing temprature. This change can affect the electrical and optical properties of the material.

(iv) Thermal runway:- Higher tempratures can lead to thermal runway in some devices; potentially causing failure or degradation of performance.

(iii) ON INSULATORS

Temperature has several important effects on insulators.

i) Thermal Conductivity :- As temperature increases, the thermal conductivity of insulators generally increases, leading to better heat transfer. However, this can also lead to increased heat buildup in electronic devices.

In this modern era of microelectronics, signals plays very vital roles. It has diverse applications in area of science and technology such as - circuit design, seismology, communications, biomedical, engineering etc.

-: SIGNAL :-

- signal may be a function of time, temperature, Position, pressure, distance etc.
- Example of signals in our daily life are music, speech, picture and video signals.
- systematically we can define a signal as " A function of one or more independent variables which contains some information is called signal".

· Types of Signals.

In day-to-day life, we come across various types of signals.

- The signals may be broadlly classified into following two categories.

(i) Analog Signals.

(ii) Digital Signals. (o) + Co2

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-: Analog signals :-

Analog signals are used to create information-carrying signals in a variety of systems. Both in terms of quantities and time, these signals are continuous. As technology evolved, digital transmissions repealed the use of analog signals.. Signals that are natural to or occur naturally are analog signals.

Example :- Any natural sound, human voice and data read by analog devices are examples of analog signals.

-: characteristics of analog signal :-

Analog signal denote a voltage or any physical quantity that is continuous and invariable and fluctuates in it's quantity based on the parameter whose behaviour changes according to time these can be radio waves, broadcast waves.

Further classification of analog signals based on characterists.

-: Continuous - time signals and discrete - time signals :-

Analog signal processing make use of the electronic devices to conduct several operations on the signals. These can be ranging from amplification to limiting. certain tools used in processing analog signals are analog generators power supply.. oscilloscopes and certain other electronic equipment.

-: measuring analog signals :-

~~A digital~~ A For an analog signal, its amplitude is measured in volts while the frequency of an analog signals is measured in Hertz. Thus analog signals carry three categories of information amplitude, frequency and phase.

-: Digital signals :-

A digital signal is one that is a discrete function of time rather than a continuous signal. Digital signals are binary in nature and consist of discrete voltage values at discrete times. A digital signal, in essence, represents data and information as a sequence of discrete values at any given time. The digital signal has a limited number of values.

-: Characteristics of digital signals :-

The digital signal is a discrete delivery time and is a non-continuous signal. The bandwidth of digitals is very high so, they are highly suitable for functions such as computing, digital operations, data storage. These digital signals have wave function represents digital signals. These digital signals have fewer fluctuations, healthier instability, and do not fall prey to noise and disturbances, unlike analog signals.

Difference between Analog signals and Digital signals.

	Analog signal	Digital signal
1.	Analog signals are used to communicate information in a continu--ous function of time	A digital signal transmits data in a discrete function of time.
2.	Analog signals represent data and information using a continuous range of various.	Digital signals use discrete values 0 and 1
3.	The bandwidth is low.	The bandwidth is high.
4	Analog signals are better suited for transmitting audio, video and other data via communication channels.	The digital signals are appropriate for processes such as data storage and other things.
5.	Analog signals are easily influenced by electrical noise.	Digital signals are noise free; they have high accuracy.
6.	Resistors, capacitors, indu--ctors, and other components	Transistors, logic gates, ICs, etc.
7.	Used in landline phones thermometers, radios, and other devices.	Used in computers, keyboards, digital watches, and other electronic devices.

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2. NUMBER REPRESENTATION.

• Number system :-

• It is a mechanical language that provides a facility to make the numbers.

• we may define a number system which conist of

(i) A set of symbol used for formation of numbers.

(ii) A set of rules which may be used to form numbers from these symbols and assign values to them.

(iii) A set of rule performing common arithmetic operation on this system.

• Some important number systems are given below.

(i) Decimal number (ii) Binary number system. etc.

1) Decimal number system.

• The number system has a base of 10, i.e, 0, 1, 2, 3, 4, 5, 6, 7, 8, 9,

• For examples

The number 456 can be written as

$$4 \times 10^2 + 5 \times 10^1 + 6 \times 10^0$$

2) Binary Number system

• The binary number system, numbers can be represented using 2 digits only so the base of binary number system is 2.

• The two digits that are used in binary number system are 0 and 1

$$(1010) = (1 \times 2^3) + (0 \times 2^2) + (1 + 2^1) + (0 + 2^0)$$

$$= 1 \times 8 + 0 \times 4 + 1 \times 2 + 0 \times 1 = 10$$

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This means $(1010)_2 = (10)_{10}$

3) Octal Number system

- Octal number system is the number system with base 8. This means, in this number system there are 8 symbols or digits which are used for formation of the numbers.
- These symbols are 0, 1, 2, 3, 4, 5, 6 and 7

Example $(156)_8 = 6\times8^0 + 5\times8^1 + 1\times8^2$

$= 6\times1 + 5\times8 + 1\times64$

$= 6+40+64$

$= 110$

$(156)_8 = (110)_{10}$

4) Hexadecimal Number system.

- This number system is number system with base 16.
- Using the symbols 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E and F are used to represent the numbers 10, 11, 12, 13, 14 and 15 respectivily.

Example:- $(13BD)_{16} = 1\times16^3 + 3\times16^2 + 13\times16^1 + D\times16^0$

$= 4096 + 768 + 11\times16 + 13\times1$

$= 4096 + 768 + 176 + 13$

$= 5053$

$(13BD)_{16} = (5053)_{10}$

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BASE CONVERSION

Decimal to Binary

$(45)_{10} - (?)_2$

2	45		LSD
2	22	– 1	
2	11	– 0	
2	5	– 1	
2	2	– 1	
2	1	– 0	
	0	– 1	MSD

$(45)_{10} - (101101)_2$

$(0.8176)_{10} - (?)_2$

MSD	0	0.8176×2
	1	0.6352×2
	1	0.2704×2
	0	0.5408×2
	1	0.0816×2
LSD	0	0.1632×2

$(0.8176)_{10} = (0.11010)_2$

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$(67.25)_{10}$:- $(?)_2$

* First we convert the integral part into binary equivalent.

2	67	
2	33	– 1
2	16	– 1
2	8	– 0
2	4	– 0
2	2	– 0
2	1	– 0
	0	– 1

Now we convert the decimal part.

0	0.25×2
1	0.50×2
1	0.00×2

Thus $(67.25)_{10} = (1000011.01)_2$

Binary to decimal :-

$(1100111)_2$ – $(?)_{10}$

$(1100111)_2 = 1\times2^6 + 1\times2^5 + 0\times2^4 + 0\times2^3 + 1\times2^2$
$+ 1\times2^1 + 1\times2^0$

$= 64 + 32 + 0 + 0 + 4 + 2 + 1$

$= (103)_{10}$

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$(11001101.01)_2 = (?)_{10}$

$1\times2^7 + 1\times2^6 + 0\times2^5 + 0\times2^4 + 1\times2^3 + 1\times2^2 + 0\times2^1 + 1\times2^0$
$+ 0\times2^{-1} + 1\times2^{-2}$

$= 128 + 64 + 0 + 8 + 0 + 1 + 0.25$

$(205.25)_{10}$

* Group of binary digits from octal.

0	000
1	001
2	010
3	011
4	100
5	101
6	110
7	111

* Group of Binary digits from one hexdeci-mal.

Hexdecimal digit	Binary equivalent.
0	0000
1	0001
2	0010
3	0011
4	0100
5	0101

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6	0110
7	0111
8	1000
9	1001
10-A	1010
11 or B	1011
12 or C	1100
13 or D	1101
14 or E	1110
15 or F	1111

* Binary operations *

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* ASCII code

- ASCII stands for American standard code for information interchange.
- The code specifies a dispatching, in which each sign of Latin alphabet and each Arabic number corresponds to a clear value.
- This standardization now made information exchange possible between different ~~bet~~ computer systems.
- The code uses 7 bits to encode 128 unique characters.

:BCD Codes :-

- Binary coded decimal (BCD) is a way of expre--ssing each of the decimal digits with a binary code.
- There are only ten code groups in the BCD system, so it is very easy to convert between decimal to BCD.
- The 8421 code is a type of BCD code.
- Binary coded decimal means that each decimal digit 0 through 9, is represented by a binary code of fou bits.

Decimal digit	BCD code.
0	0000
1	0001
2	0010
3	0011
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001

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(BCD codes)

BCD :- 'Binary coded decimal is the way of expressing each and every decimal with binary code.

There are only 10 group of codes in binary system, so it's easy to convert btw decimal to BCD codes.

'Binary coded decimal mean that each desimal digit 0 through 9, is represented by binary code of four bit.

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In digital electronics, a logic or logic function is one that follows the rules that governs a logical statement. Logics are implemented by ~~swi~~ using switching networks, where a switching network is one that is designed by interconnecting a finite number of switches.

Truth Table :- There is another term associated with the logic function that is the truth table. The truth tables is used for testing the performance of the logic network.

Negative Logic System :-

In the digital electronic systems, if the high value of signal (voltage or current) is used to represent the logic 0 and the low value of signal (voltage or current) is used to represent the logic 1, then it is called a negative logic system.

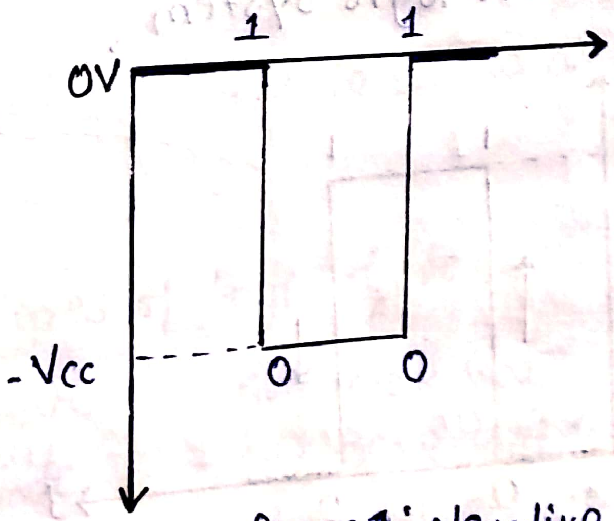

Figure 2: Negative Logic

The pulse waveform reprentation of a negative of a neg logic is shown in figure 1. In the case of negative logic, the voltage at -VCC volts level represents the logic 0 (Logic LOW), and the voltage at 0 volts levelel represents the logic 1 (Logic HIGH).

Higher Voltage = Logic LOW (0)

Lower Voltage = Logic HIGH (1)

Example:- Consider a PNP transistor, If the transistor is OFF, then its output will be at -VCC volts that representes the logic 0 (LOW) state. On the other hand, if the transistor is ON, then its output will be 0 volts, and it represents the logic 1 (HIGH) state.

-: Positive Logic system :-

In digital electronic systems, if the high value of signal (voltage or current) is used to represent the logic 1 and the low value of signal (voltage or current) is used to represent the logic 0, then it is called a positive logic system.

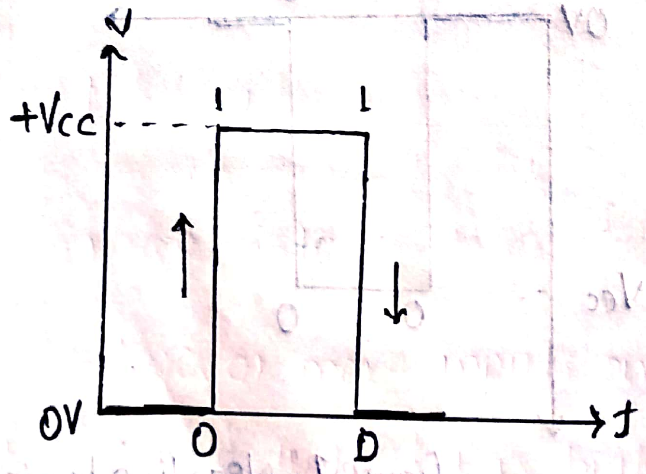

Figure 2 Positive Logic

The pulse waveform representation of a positive logic is shown in figure 2 In the case of positive logic, the voltage at 0 volts level represents the logic 0 (Logic LOW) and the voltage at +Vcc volts level represents the logic 1 (Logic HIGH)

Higher Voltage = Logic HIGH

Lower Voltage = Logic LOW

Example :- Consider an NPN transistor, if the transistor is off, then its output will be at +Vcc that represents the logic 1 (HIGH) state. On the other hand, if the transistor is ON, then its output will be 0 volts, and it represents the logic 0 (LOW) state.

-: Logic Gate :-

Logic gate is a electric circuit which can take one or more input but output will be one.

Note:-

- Logic gates are made up of diodes and transistors
- A logic gate is used to allow and denied a digital signal.

-: Types of Logic Gate :-

(i) AND Gate

(ii) OR Gate

(iii) NOT Gate

(iv) NOR Gate

(v) XOR Gate

(vi) XNOR Gate

(vii) NAND Gate.

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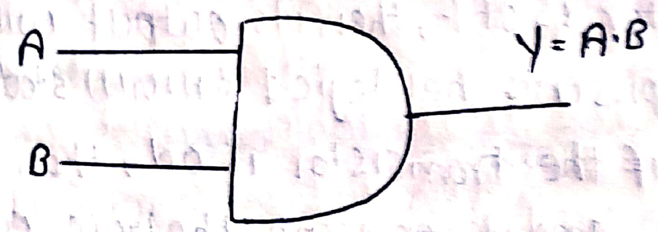
(i) AND Gate

In AND gate, whose output is high i.e 1 when the both the inputs are 1,
if a single input is 0 the output will be 0.

- AND Gate equation

$Y = A \cdot B$

- Circuit Diagram



- Truth Table

A	B	Y
0	0	0
0	1	0
1	0	0
1	1	1

(ii) OR Gate

This gate has two or more inputs and one output. If a single inyput 1 is high, the out 1 is obtained

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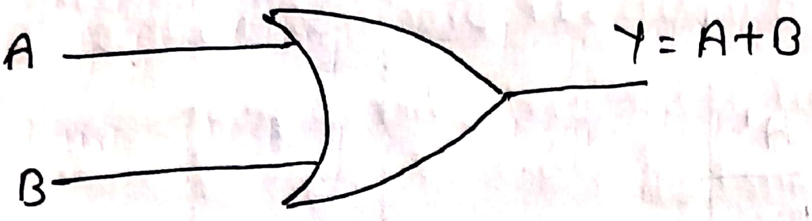
• OR Gate equation

$Y = A + B$

• Circuit Diagram



• Truth Table

A	B	Y
0	0	0
0	1	1
1	0	1
1	1	1

(iii) ~~AND~~ NOT GATE

This is an inverting gate. It is also known as inverter

• It converts high input 1 to low 0 and vice-versa.

• It has only one input and 1 output.

• In this gate output is the opposite of input.

NOT GATE equation:-

$Y = A'$

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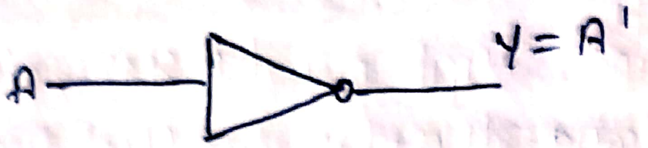
• Circuit Diagram



• Truth Table

A	Y = A'
0	1
1	0

-: Universal Gates :-

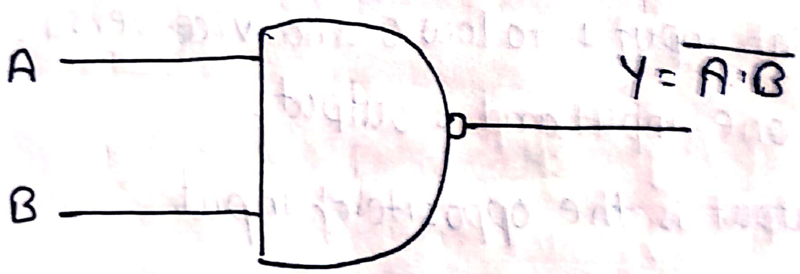
Gates those made up of the combination of two logic gates are called universal gates.

Ex:- NAND, NOR, etc.

-: NAND Gate :-

= NOT + AND ($\overline{A \cdot B}$)

• Circuit Diagram



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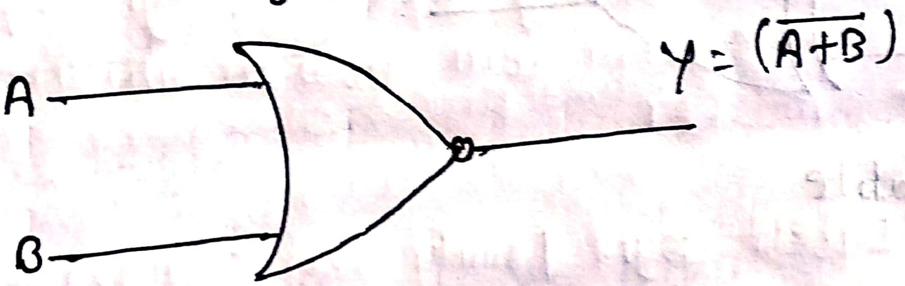
:Truth Table:-

A	B	$Y = \overline{A \cdot B}$
0	0	1
0	1	1
1	0	1
1	1	0

-: NOR Gate :-

NOR = NOT + OR ($\overline{A+B}$)

- Circuit Diagram



- Truth Table

A	B	$Y = \overline{A+B}$
0	0	1
0	1	0
1	0	0
1	1	0

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X-OR Gate :-

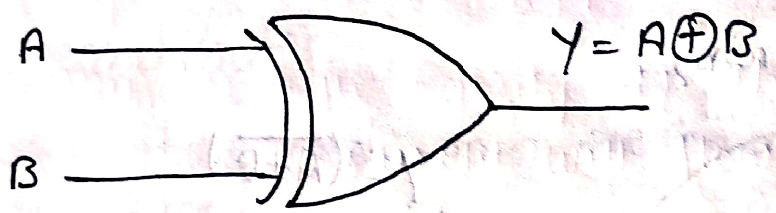
Exclusive-OR Gate.

An XOR gate is a digital logic gate that outputs true (or 1) only when the number of true input is odd. For two inputs, It produces a true output when one input is true and other is false.

- X-OR gate equation

$$Y = A \oplus B$$

- Circuit Diagram



- Truth Table

A	B	Y=A XOR B ($Y = A \oplus B$)
0	0	0
0	1	1
1	0	1
1	1	0

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-! EX NOR [illegible]:-

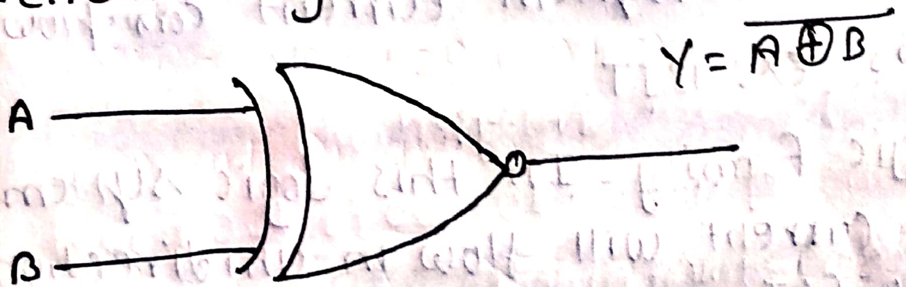
An E-NOR gate, also known as an Exclusive NOR (XNOR) gate, is a digital logic gate that outputs true or high(1) only when its two inputs are equal.

In other words, It produces a true output when both input s are either true (1) or false(0).

-: equation of X-NOR gate :-

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

• circuit Diagram



• Truth Table

A	B	$Y = \overline{A \oplus B}$
0	0	1
0	1	0
1	0	0
1	1	1

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→ Logic Family classification:-

Logic family classification catagorizes digital logic circuits based on their underlaying technology and electrical characteristics. It helps in selecting appropriate components for specific application.

According to flow of current logic families are classified in two parts

(i) Bipolar Logic family (BJT) - In this logic system current can flow in two directions. ex: BJT.

(ii) Unipolar Logic Family - In this logic system current will flow in unidirection. ex: FET, MOSFET.

* Further Bipolar logic family has catagrazied in two parts.

Bipolar logic Family

Saturated	Non-saturated
• RTL (Resistor transistor logic)	• Shott key Transistor Transistor logic
• DCTL (Direct coupled Transistor logic)	• ECL (Emittor coupled logic)
• DTL (Diode transistor Logic)	

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- IIL (Intergrated Injection logic)
- TTL (Transistor Transistor Logic)

(ii) Unipolar Logic family :-

- PMOS
  (P-channel metal oxide semiconductors)
- N mos
  (N-Channel metal oxide semiconductors)
- C-mos
  (C-channel metal oxide semiconductors)

Integrated Circuits (IC)

Integrated circuit is a circuit in which circuit Components like transistor, diode, resistance are combined togeather to perform various functions is called intigrated circuits.

— Types of IC's :—

: By the scale of integration there are 5 types of IC's explained below :-

1. SSI (Small scale integration)
- Contains a few (typically less than 10) logic gates or components.
- examples. simple logic gates (AND, OR). basic flip. flop.

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• used in very simple applications.

2. MSI (Medium scale Integration)
• Contains hundreds of gates (approximately 10 to 100)
• Example : Multiplexers, decoders, simple arithmetic circuits.
• suitable for moderate complexity application.

3. LSI (Large scale Integration) :
• Contains thousands of gates (100 to 10,000).
• Examples. Basic microprocessors, memory chips.
• Used in more complex systems like early Computers.

4. VLSI (very Large scale Integration)
• Contains millions of gates (10,000 to 1000,000)
• Examples: modern microprocessors, complex ASICs (Application specific Integrated circuits)
• Used in high performance computing and sophisticated electronic devices.

5. ULSI (Ultra Large Scale Intigration)
• Contains billions of gates (over 1000000).
• Example: Advanced microprocessors, high-capacity memory (like DRAM)
• Used in high-performance computing, enabling highly complex functionalities in compact design.

→ TTL (Transistor Transistor Logic)

TTL offers higher speed compared to the RTL & DTL

TTL is a type of digital logic that uses bipolar junction transmission and resistors to perform logic operations. TTL is known for it's speed and ease to use.

- Classification of TTL
- Standard TTL
- TTL totempole output.
- TTL open collector output.
- TTL tristat Logic

CMOS

(C-channel metal oxide semiconductors)

Complementary metal oxide semiconductor, is a technology used for constructing circuits, including microprocessors, memory chips, and amlog circuits. It is caracterized by its use of complementary and symmetrical pairs of p-type and n-type (MOSFETs (metal oxide-semiconductor field-Effect Transistors)

: Classification of cmos :-

1. Digital cmos.
2. Analog cmos.
3. Mixed cmos.

$\frac{3\times10}{2.5}$ $\frac{30}{25}$

$= 1.2$

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4. - Booleam Algebra.

Booleam algebra :- It is used to analyze and simplify the digital (logic) circui-ts.

It is also knows as Binary or logical Algebra.

Invented by Gorge Boole in 1904.

Rules of Booleam Algebra

$+ \rightarrow$ Addition $\rightarrow$ OR operation.

$\cdot \rightarrow$ multiplication $\rightarrow$ AND operation.

$A = \bar{A}$, $A = 1$ $\bar{A} = 0$

inverse operation $\rightarrow$ NOT operation.

Laws of Booleam Algebra :-

(1) Booleam addition :-

$0 + 0 = 0$

$0 + 1 = 1$

$1 + 0 = 1$

$1 + 1 = 1$

(2) Booleam multiplication :-

$0 \cdot 0 = 0$

$0 \cdot 1 = 0$

$1 \cdot 0 = 0$

$1 \cdot 1 = 1$

(3) Commutative law.

$A + B = B + A$

If $0 + 1 = 1 + 0 \Rightarrow 1$

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$A \cdot B = B \cdot A$

of $1 \cdot 0 \neq 1 \cdot 0 \Rightarrow 0$

(4) Associative law.

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

Ex. $0 + (1+0) = (0+1)+0$

$0+1 = 1+0$

$1 = 1$

- $A \cdot (B \cdot C) = (A \cdot B) \cdot C$

(5) Distributive Law.

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

ex. $1 + 0 \times 1 = (1+0)(1+1)$

$1 + 0 = 1 \times 1$

$1 = 1$

- $A \cdot (B+C) = A \cdot B + A \cdot C$

(6) Absorption Law.

- $A + AB = A$

ex: $A = 1 \quad B = 0$

$1 + 1 \times 0 = 1$

$1 = 1$

Proof $A \cdot 1 + A \cdot B = A$

$A(1+B) = A$

$A \cdot 1 = A$

$A = A$

- $A(A+B) = A$

Proof $A \cdot A + AB = A$

$A + AB = A$

$A(1+B) = A$

$A \cdot 1 = A$

$A = A$

-: Key points :-

$A + 0 = A$

$A \cdot 1 = A$

$A + 1 = 1$

$A \cdot 0 = 0$

$A + A = A$

$A \cdot A = A$

$A + \overline{A} = 1$

$\overline{\overline{A}} = A$

$A \cdot \overline{A} = 0$

$A \cdot A = A$

-: Demorgon's Theorem :-

Demogrgon's theorems are used to minimize or simplify any boolean algebra.

-: Here are two theorems given by demorgon's :-

(i) Demorgan's first Theorem :-

The first theorem of Demorgan's law defines that the inverted result from AND operation is the same as the OR operation of the complement of each variable.

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

(ii) Demorgan's second Theorem :-

The second theorem of Demorgan's law defines that the inverted result from OR operation is the same as the AND operation of the complement of each variable.

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

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:- Truth Table for Demorgan's first Law :-

A	B	AB	$\overline{AB}$	$\overline{A}$ ·	$\overline{B}$	$\overline{A}+\overline{B}$
0	0	0	1	1	1	1
0	1	0	1	1	0	1
1	1	1	0	0	0	0
1	0	0	1	0	1	1

—: Truth Table for Demorgan's Second Law :-

A	B	A+B	$\overline{A+B}$	$\overline{A}$	$\overline{B}$	$\overline{A}\cdot\overline{B}$
0	0	0	1	1	1	1
0	1	1	0	1	0	0
1	0	1	0	0	1	0
1	1	1	0	0	0	0

Example :-

Prove :- $AB + BC + \overline{B}C = AB + C$.

Sol^n :- L.H.S.

$AB + BC + \overline{B}C$

$AB + C(B + \overline{B})$

$AB + C \cdot 1$

$AB + C$ R.H.S

(2) simplify $Y = \bar{A}\bar{B}\bar{C} + \bar{A}B\bar{C} + A\bar{B}\bar{C} + AB\bar{C}$

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

$Y = \bar{A}\bar{C}\cdot 1 + A\bar{C}\cdot 1$

$Y = \bar{A}\bar{C} + A\bar{C}$

$Y = \bar{C}(\bar{A}+A)$

$Y = \bar{C}\cdot 1$

$Y = \bar{C}$

:- Duality Theorem :-

A Boolean relation can be written to another Boolean relation by changing each OR operation to AND operation and vice versa.

Ex:-

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

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

$\left\{ \begin{array}{l} \cdot \text{ AND} \\ + \text{ OR} \end{array} \right\}$

Karnaugh Map (K-Map) :-

K-map is the technique of minimization the Boolean Expression.

In K-map, there are 2^n cells.

where $n \rightarrow$ no. of variables.

POS or SOP form is represented on the K-map

:- Two variable K-map :-

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

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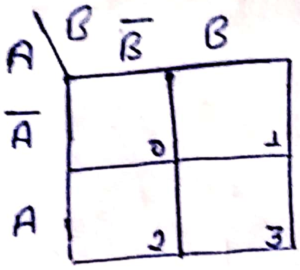
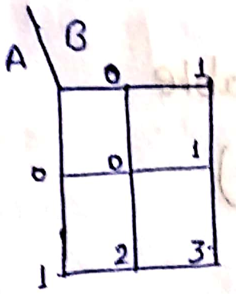
$2^2 = 4$ cells

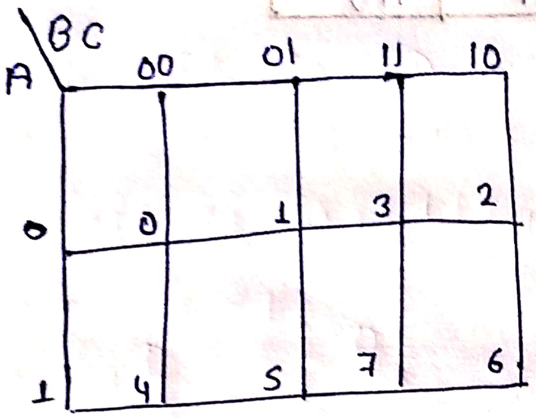




:- Three variable K-map:-

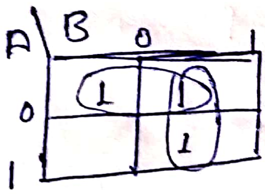
$Y = ABC + \overline{A}BC + AB\overline{C}$

$2^3 = 8$ cells

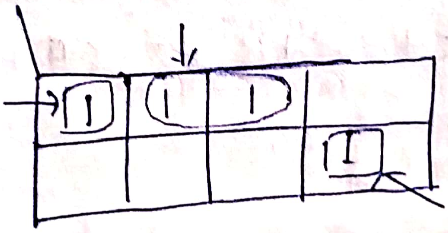


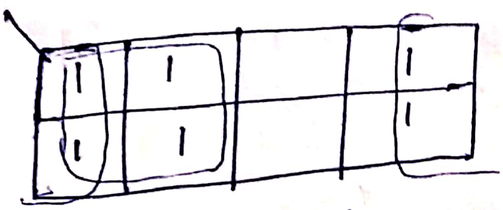
:- Rules:-

- Grouping will in form of $2^n \rightarrow 1, 2, 4, 8, 16$

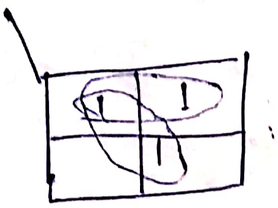


overlaping.





outerside grouping



group can't be formatted in the dia-
-gonal.

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Problem

$f = \Sigma(1,2)$

ex:- for 3 variable

function $f(A,B,C)$

A \ BC	00	01	11	10
0	0 000	1 001	3 011	2 010
1	4 100	5 100	7 111	6 110

Duality Theorem:-

To get the dual of any Boolean expression, replace

$\cdot \leftrightarrow +$ $\quad + \leftrightarrow \cdot$

OR $\longleftrightarrow$ AND

XOR $\longleftrightarrow$ XNOR

NAND $\longleftrightarrow$ NOR

$0 \longleftrightarrow 1$

$0 \longrightarrow 0$

$A \to A$

$\bar{A} \to \bar{A}$

$B \to B$

$\bar{B} \to \bar{B}$

$A \cdot \bar{A} = 0$

find the dual of

(i) $\bar{A}B + A\bar{B}$

$(\bar{A}+B) \cdot (A+\bar{B})$

$\bar{A} \cdot A + \bar{A}\bar{B} + B \cdot A + B\bar{B}$

$\bar{A}\bar{B} + B \cdot A$

(ii) $(A \cdot B\bar{C}) + (\bar{A}BC)$

$(A+B+\bar{C}) \cdot (\bar{A}+B+C)$

$\Rightarrow A \cdot \bar{A} + AB + AC + B \cdot \bar{A} + B \cdot B + BC + \bar{C}\bar{A} + \bar{C} \cdot B + \bar{C}C$

$\Rightarrow AB + AC + B \cdot \bar{A} + B + BC + \bar{C}\bar{A} + \bar{C} \cdot B.$

Complement:-

To find the complement of any boolean expression, replace.

OR $\longleftrightarrow$ AND

$0 \longleftrightarrow 1$

$A \longleftrightarrow \bar{A}$

$\bar{A} \longleftrightarrow A$

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Arithmetic Circuits :-

Arithmetic circuits are fundamental blocks in digital systems and are used for airthmetic operations such as addition, substraction, multiplication and division.

Adder Circuit :-

Adder circuits are basic arithmetic circuits which are used for binary addition. They come in various types based on their complexity and function. They come in various types based on their complexity and function.

1. Half Adder :-

A half adder is a basic type of adder circuit, which is used in many digital designs. It performs the addition of two one-bit binary numbers and generates an output in terms of sum and carry. The half adder consists of two logic gates: an XOR gate for the sum and an And gate for the carry.

Inputs		Output	
A	B	Sum	Carry
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

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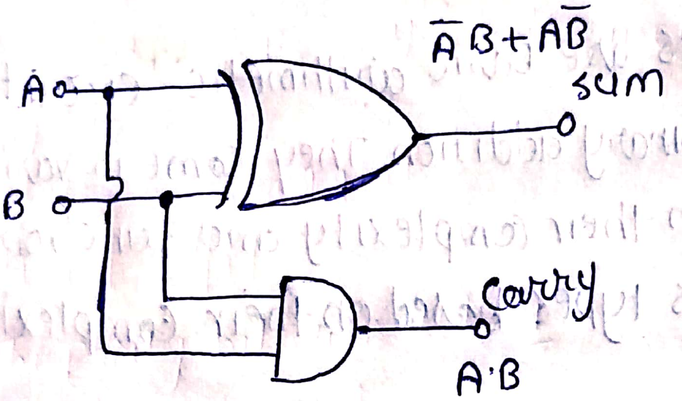
-: Boolean equation :-

sum = $\bar{A}B + A\bar{B}$ (EX-OR gate)

carry = $A \cdot B$



(ii) Full adder :- A full adder is an improvement of the half adder since it perform addition of three binary numbers (two inputes and a carry from the previous addition). It produces a sum and a carry. It is made of two half adders and OR gate for the carry.

-: Truth Table :-

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

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equation:-

$$sum = \bar{A}\bar{B}C + \bar{A}B\bar{C} + A\bar{B}\bar{C} + ABC$$

$$= \bar{A}(\bar{B}C + B\bar{C}) + A(\bar{B}\bar{C} + BC)$$

$$= A(\underbrace{B \oplus C}_{x}) + A(\underbrace{\overline{B+C}}_{\bar{x}})$$

$$= Ax + A\bar{x}$$

$$= A \oplus x \Rightarrow A \oplus B \oplus C$$

$$carry: \bar{A}BC + A\bar{B}C + AB\bar{C} + ABC$$

$$=$$

Parity Generator and Parity Checker :-

* Parity bits are the error detecting codes.

→ Parity (odd or Even) :-

① odd parity :-

Total number of 1's in the code, including the Parity bit should be odd.

Data bits							Parity bits
1	0	1	1	0	0	1	X

The parity bit would be 1

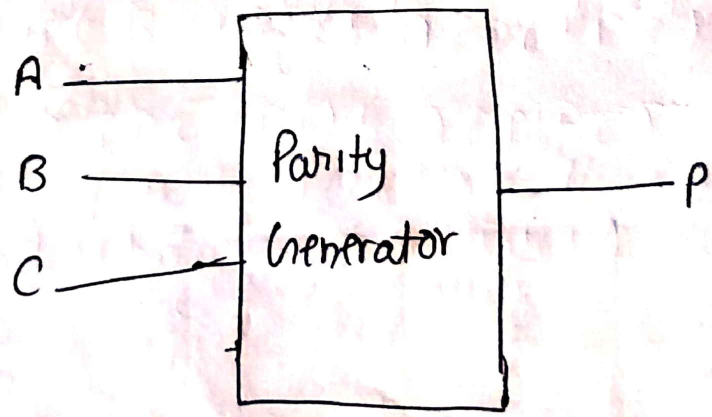
② Even parity :

Total No. of 1's in the code, including the parity bit should be even.

Ex.

Data Bit							Parity Bit
1	1	0	0	1	1	0	X

The parity bit would be zero



A	B	C	P
0	0	0	0
0	0	1	1
0	1	0	1
0	1	1	0
1	0	0	1
1	0	1	0
1	1	0	0
1	1	1	1

$P = \bar{A}\bar{B}C + \bar{A}B\bar{C} + A\bar{B}\bar{C} + ABC$

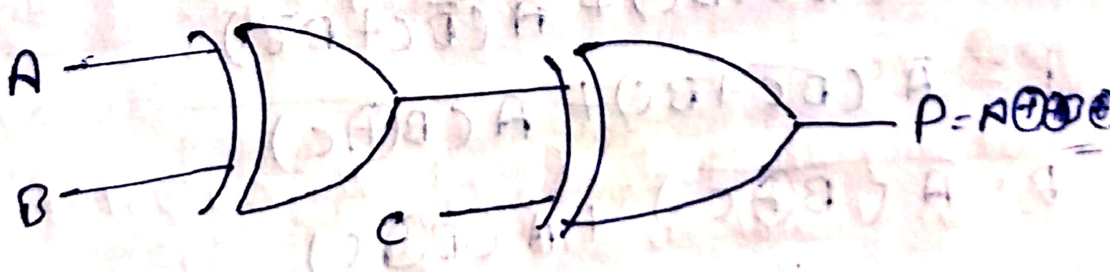
$P = \bar{A}(\bar{B}C + B\bar{C}) + A(\bar{B}\bar{C} + BC)$

$P = A(B \oplus C) + A(\overline{B \oplus C})$

$B \oplus C = x$

$P = Ax + A\bar{x}$

$P = A \oplus x$, $P = A \oplus B \oplus C$



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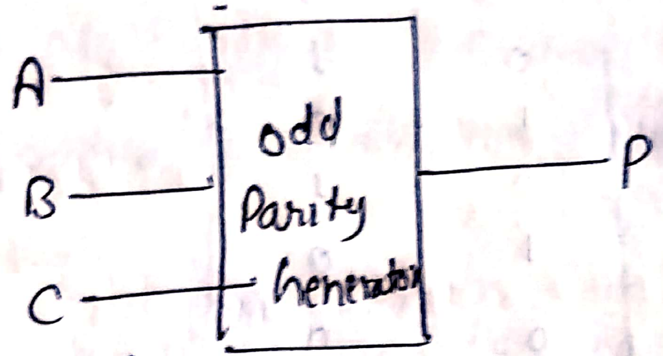
→ Odd Parity Generator :-



A	B	C	P
0	0	0	1
0	0	1	0
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	0

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

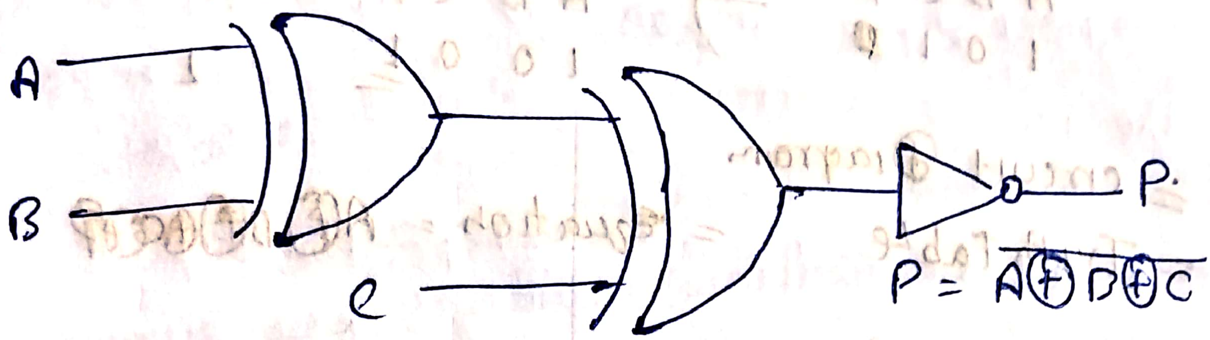
$$P = \bar{A}(\bar{B}\bar{C} + BC) + A(\bar{B}C + B\bar{C})$$

$$P = \bar{A}(\bar{B}\bar{C} + BC) + A(B \oplus C)$$

$$P = \bar{A}(\underbrace{\overline{B \oplus C}}_{\bar{x}}) + A(\underbrace{B \oplus C}_{x})$$

$$P = \bar{A}\bar{x} + Ax$$

$$P = \overline{A \oplus B \oplus C}$$



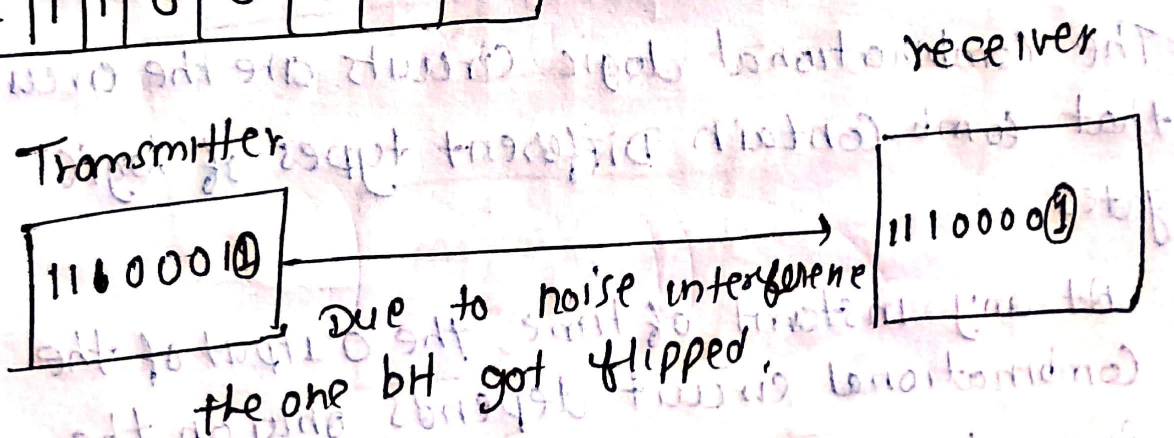
$P = \overline{A \oplus B \oplus C}$

odd parity checker

Parity check :- Parity checker will check the Parity of the received code, and it will decide, whether the received code is correct or not.

odd parity Data Bit. ParityBit

1	1	1	0	0	0	1	1



Even Parity Checker

A B C P → A B C P check
1 0 1 0 → 1 0 0 1 1

= circuit Diagram
= Truth Table = Equation = $A \oplus B \oplus C \oplus P$

odd Parity checker

A B C P → A B C P check
1 0 1 1 → 1 0 0 1 1

= Circuit Diagram.
= Truth Table = equation = $\overline{A \oplus B \oplus C \oplus P}$

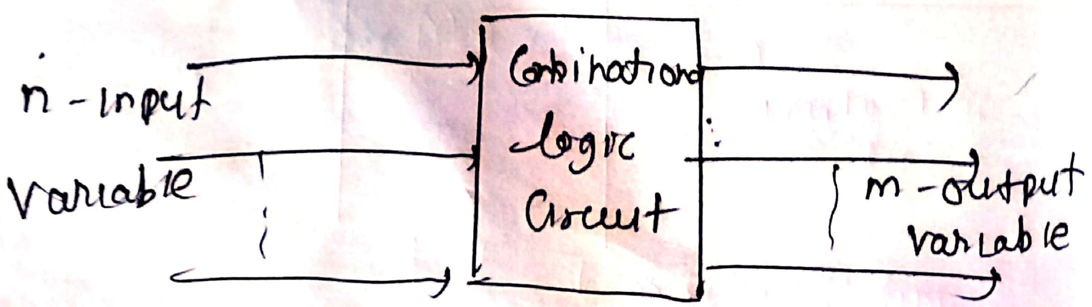
{ Combinational logic Circuits and sequential logic circuits }

CLC

1	1	0	0	0	1	1

= The Combinational logic circuits are the circuits that ~~comb~~ Contain Different types of logic gates.

= At any instant of time, the output of the Combinational circuit depends only on the Present input terminals.



= The Combinational circuit Doesn't have any backup or previous memory. The present state of the circuit is not affected by the previous state of the input.

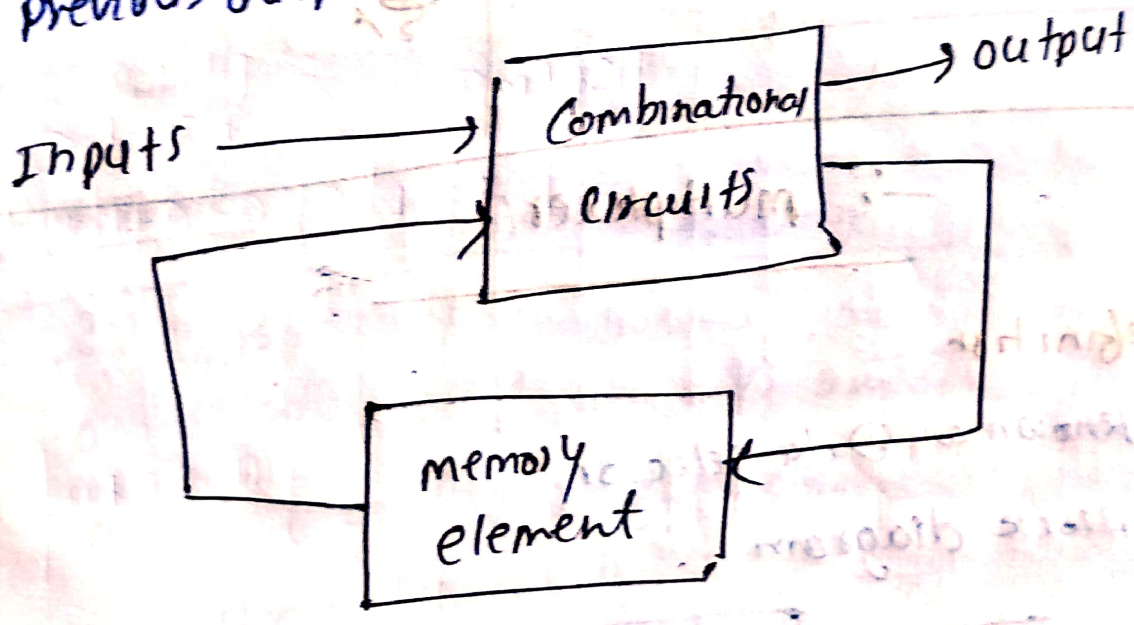
= The n number of input and m number of outputs are possible in Combinational logic circuits

Ex:- Half adder, full Adder, etc.

SLC

= Sequential Circuit is a special type of circuit that has a series of inputs and outputs

= The output of sequential circuits depends on both the combination of present input and previous output (present state)



Ex. Latch, flip-flops

Combinational Circuit V/S Sequential Circuit

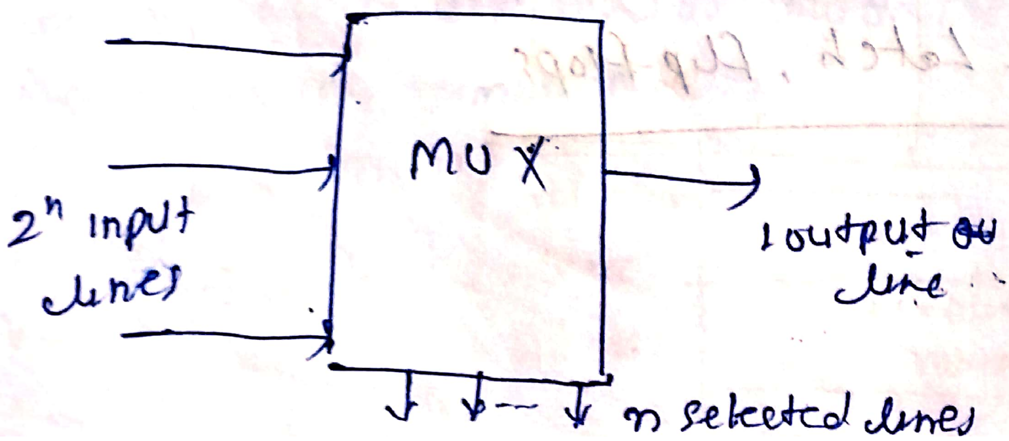
Combinational Circuit	Sequential Circuit
1) output depend only on the present input	1) Output depend on both present input & previous output
2) Feedback path is not present.	2) Feedback path is present.
3) The clock signal is not required.	The clock signal is required.
4) memory elements are not required.	4) memory element play an important role and required.
5) It is simple to design	5) It is not simple to design.
Ex:	Ex

:- multiplexer :-

Definition

= Known as Data selector.

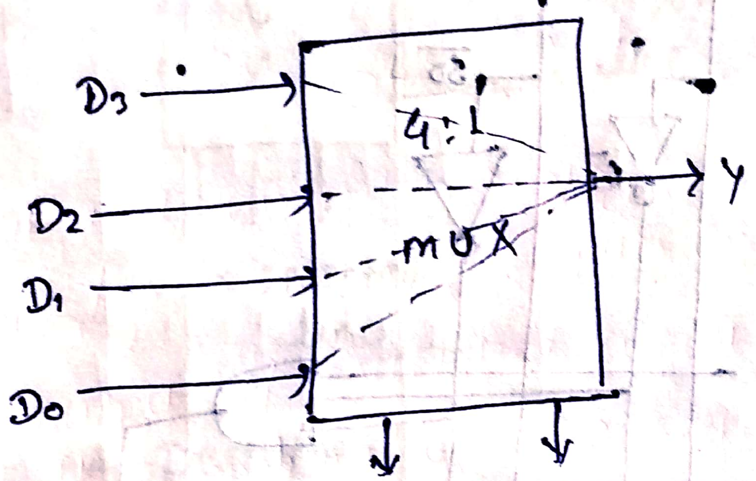
. Block diagram



2^n - input
n - selected lines → MUX → 1 output

4:1 mux

$y = 2^2 = 4$ inputs
$n: 2$ = selective lines.
1 = output.



S1 S0
0 0
0 1
1 0

TT - selective

Truth Table

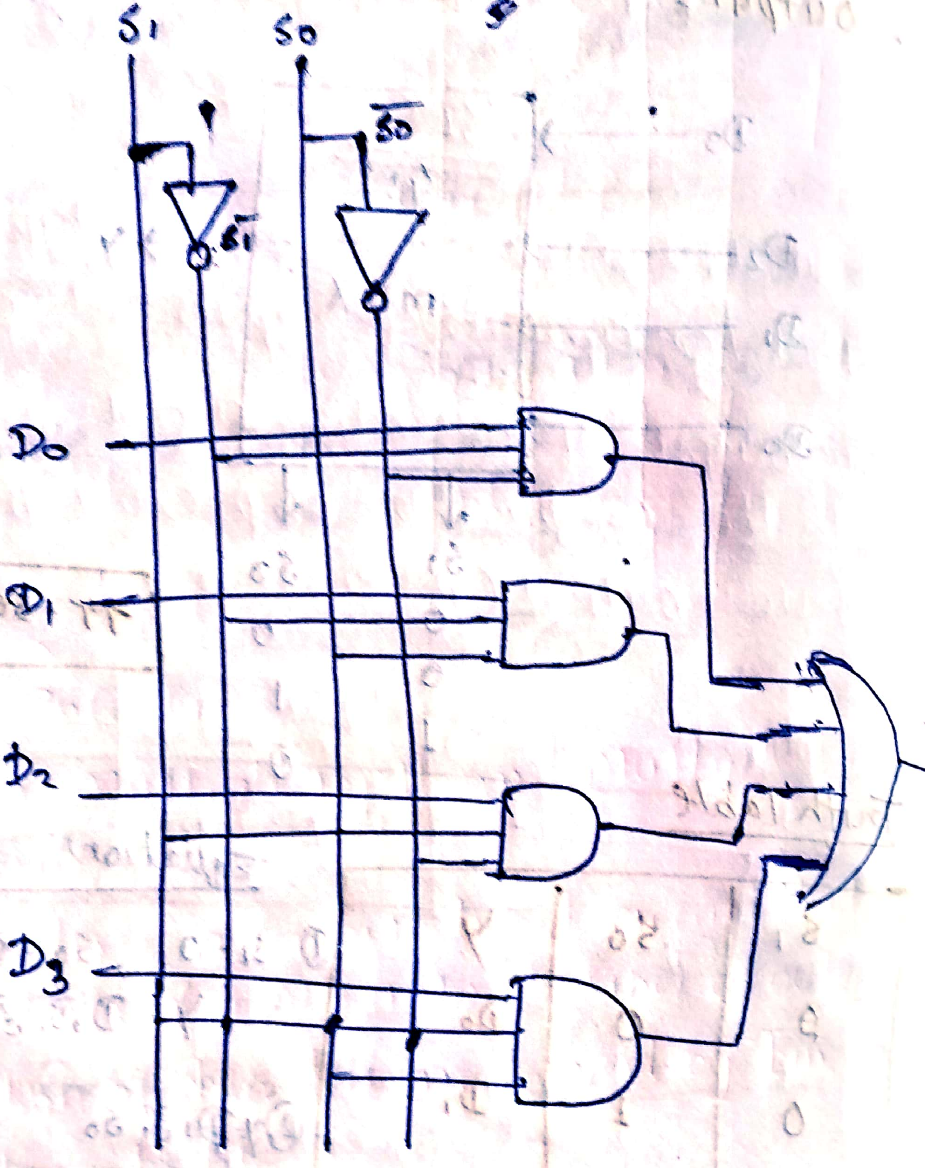
S1	S0	Y
0	0	D0
0	1	D1
1	0	D2
1	1	D3

Equations

1. $S_1 = 0$, $S_0 = 0$
   $Y = D_0 \bar{S_1} \bar{S_0}$
2. $Y = D_1 \bar{S_1} S_0$
3. $Y = D_2 S_1 \bar{S_0}$
4. $Y = D_3 S_1 S_0$

$Y = D_0\bar{S_1}\bar{S_0} + D_1\bar{S_1}S_0 + D_2 S_1\bar{S_0} + D_3 S_1 S_0$

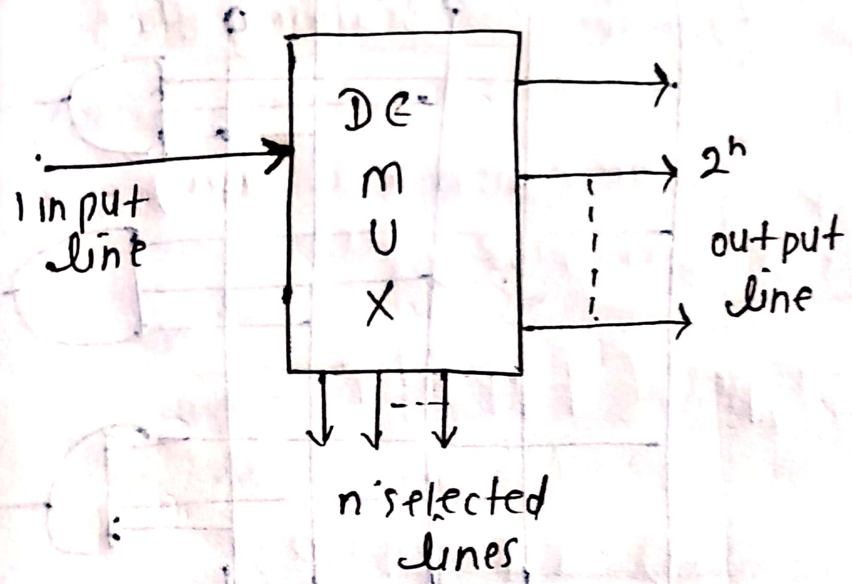
$Y =$



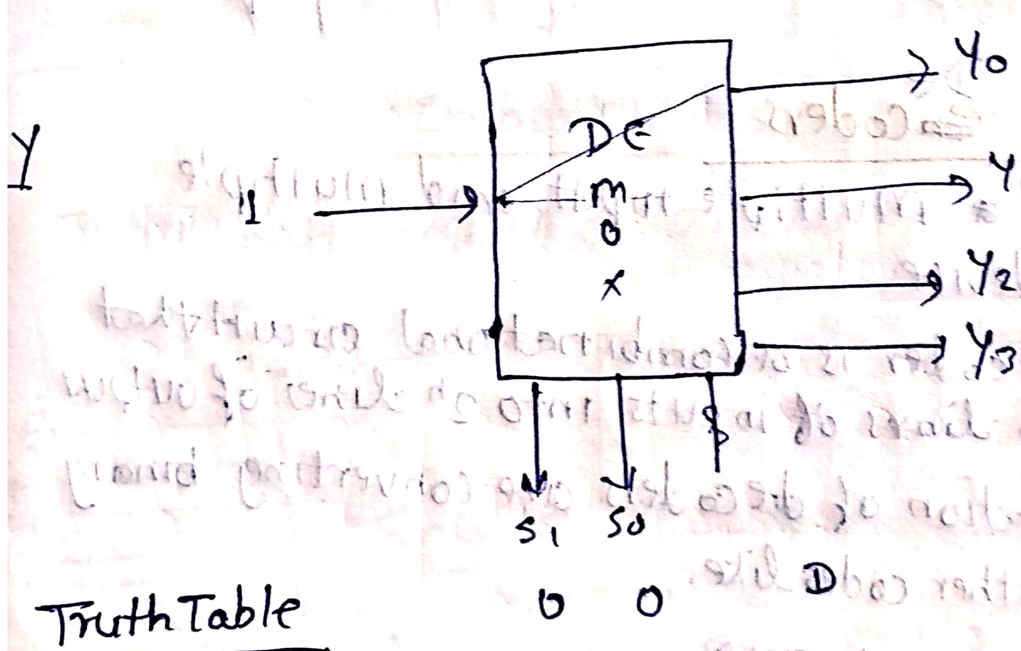
Demultiplexer

⇒ Also called as data distributer.

Block diagram :-



1: 4 Demux



Truth Table

Data	Select line		output			
D	S_1	S_0	Y_0	Y_1	Y_2	Y_3
D	0	0	D	0	0	0
D	0	1	0	D	0	0
D	1	0	0	0	D	0
D	1	1	0	0	0	D

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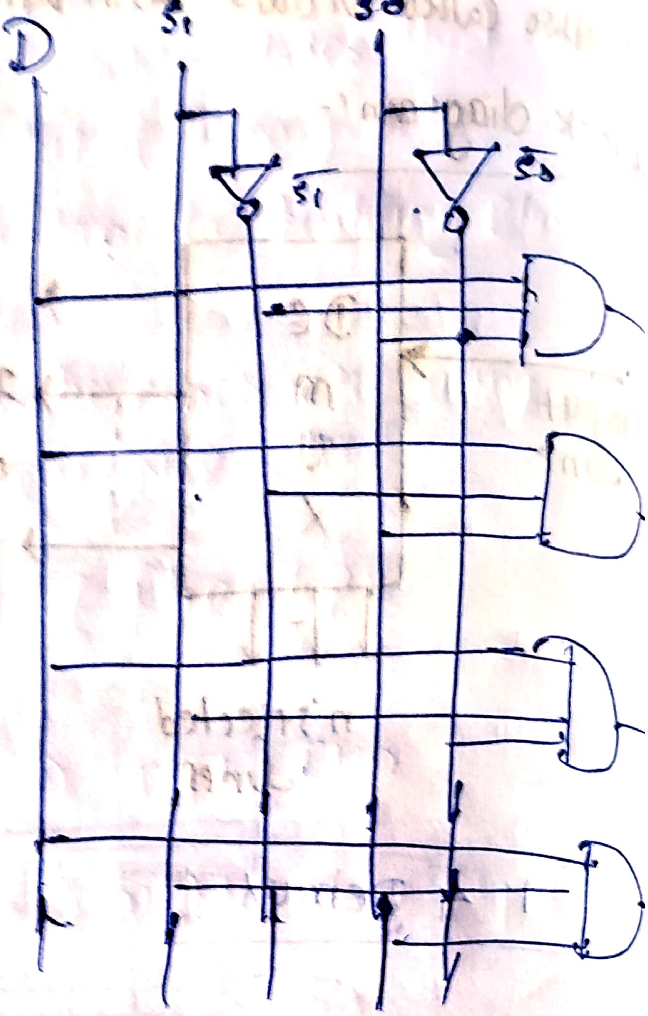
$Y_0 = D\overline{S_1}\,\overline{S_0}$

$Y_1 = D\overline{S_1}\,S_0$

$Y_2 = D\,S_1\overline{S_0}$

$Y_3 = D\,S_1 S_0$



~~En~~ Decoders

→ It is a multiple input and multiple output device.

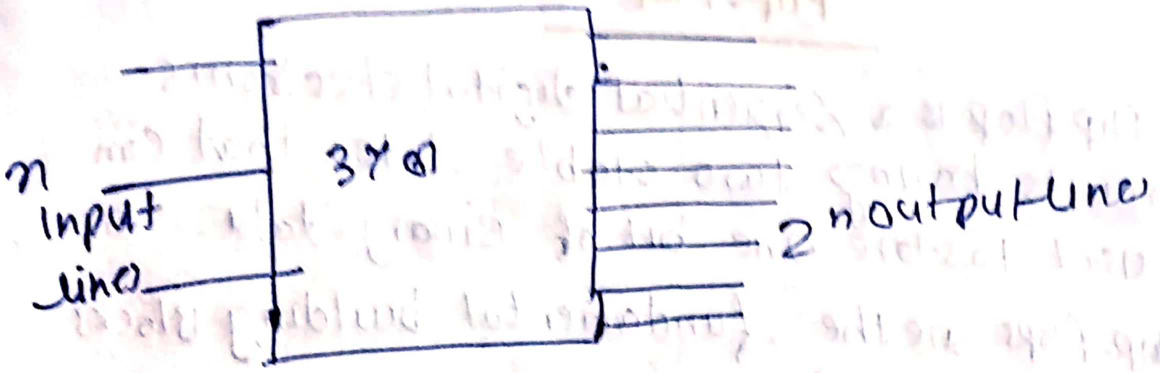
→ ~~De~~ Decoder is a combinational circuit that converts n lines of inputs into 2^n lines of outputs.

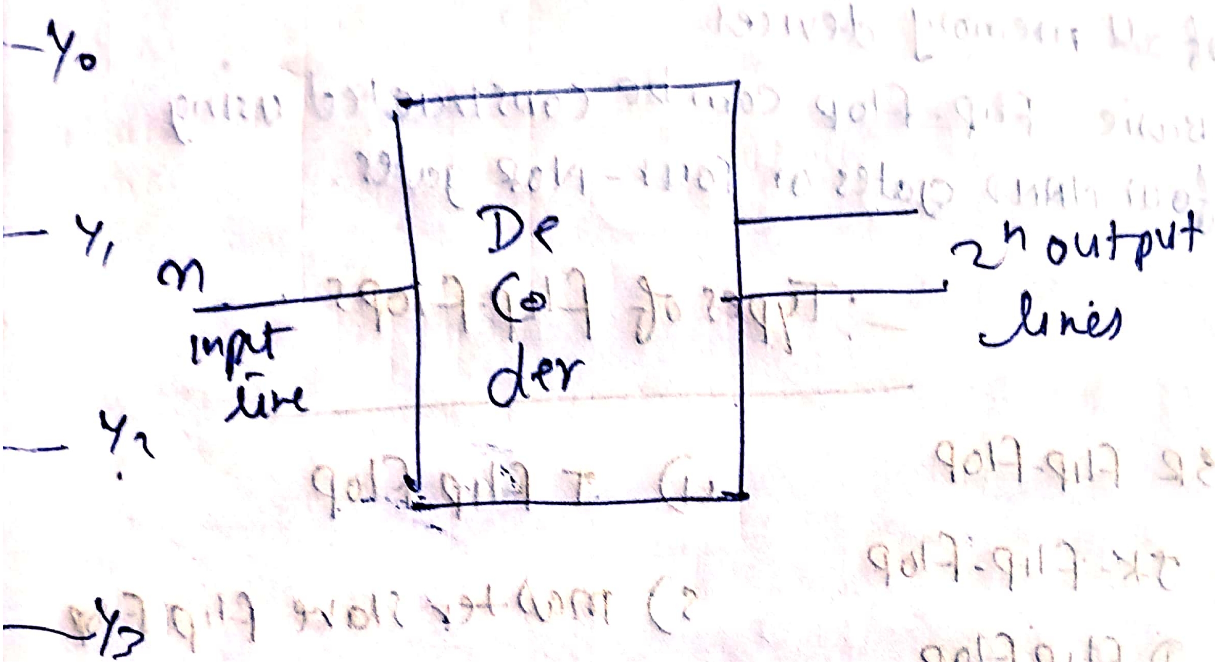
• Application of decoders are converting binary code to other codes like.

, Binary to octal. 3×8

• Binary to Hexdecimal. 4×16

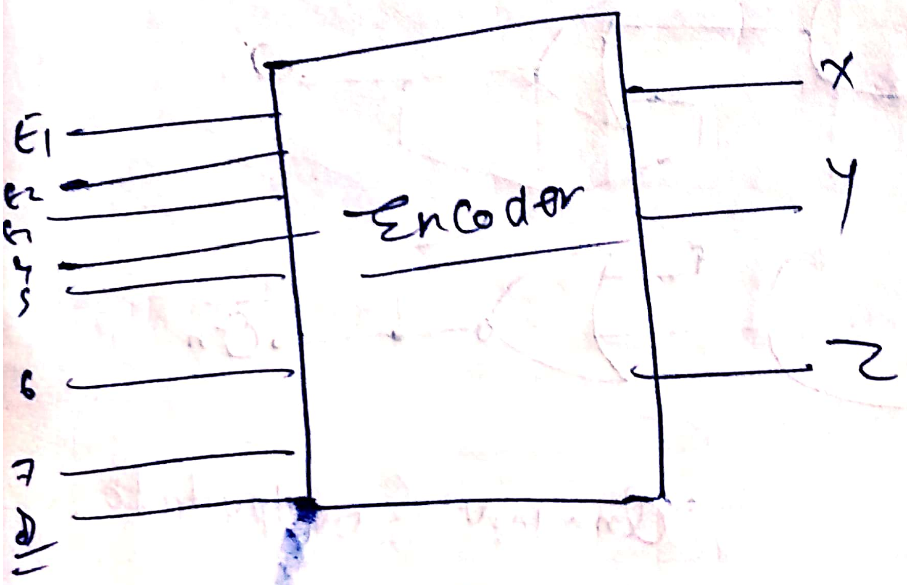
• Binary to decimal 4×10





Encoder

→ 2^n input and n output lines



Flip-Flop

→ A flip flop is a sequential digital electronic circuits having two stable states that can be used to store one bit of Binary data.

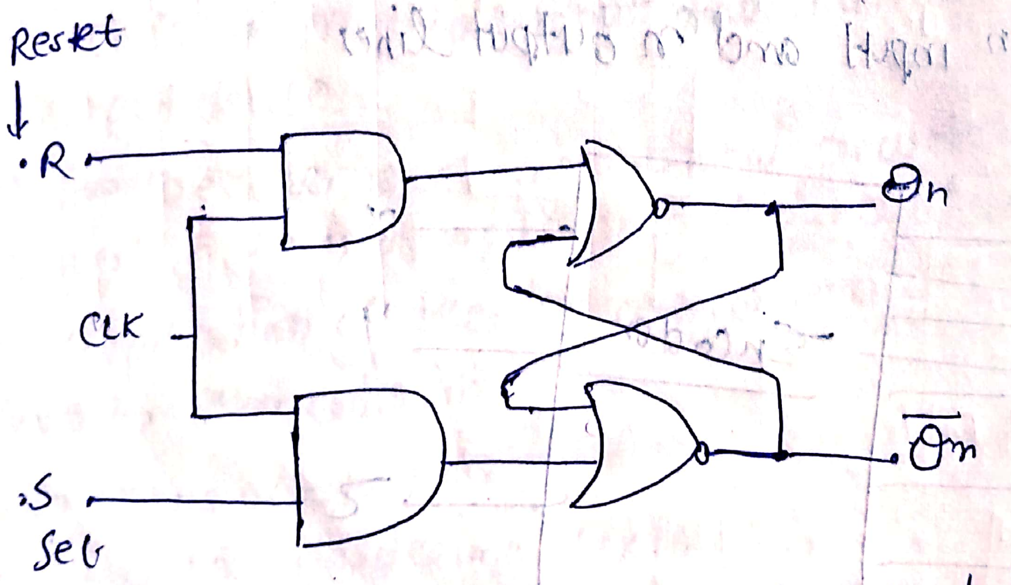
→ flip-flops are the fundamental building Blocks of all memory devices.

→ Basic. Flip-Flop can be constructed using four NAND gates or four-NOR gates.

—; Types of flip-flops :-

1) SR Flip-Flop
2) JK-Flip-Flop
3) D Flip Flop
4) T Flip Flop
5) master slave flip Flop

→ SR flip flop :-



Qn- input & output also

S, and R are input

Qn main input

-: Truth Table :-

Input R	S	Q_n	Output Q_{n+1}	
0	0	0	0	No change.
0	0	1	1	
0	1	0	1	set
0	1	1	1	
1	0	0	0	Reset
1	0	1	0	
1	1	0	?	Forbidden stage.
1	1	1	?	

CLK - is always 1

S	R	Q_{n+1}
0	0	No change
0	1	set
1	0	Reset
1	1	Forbidden Stage.

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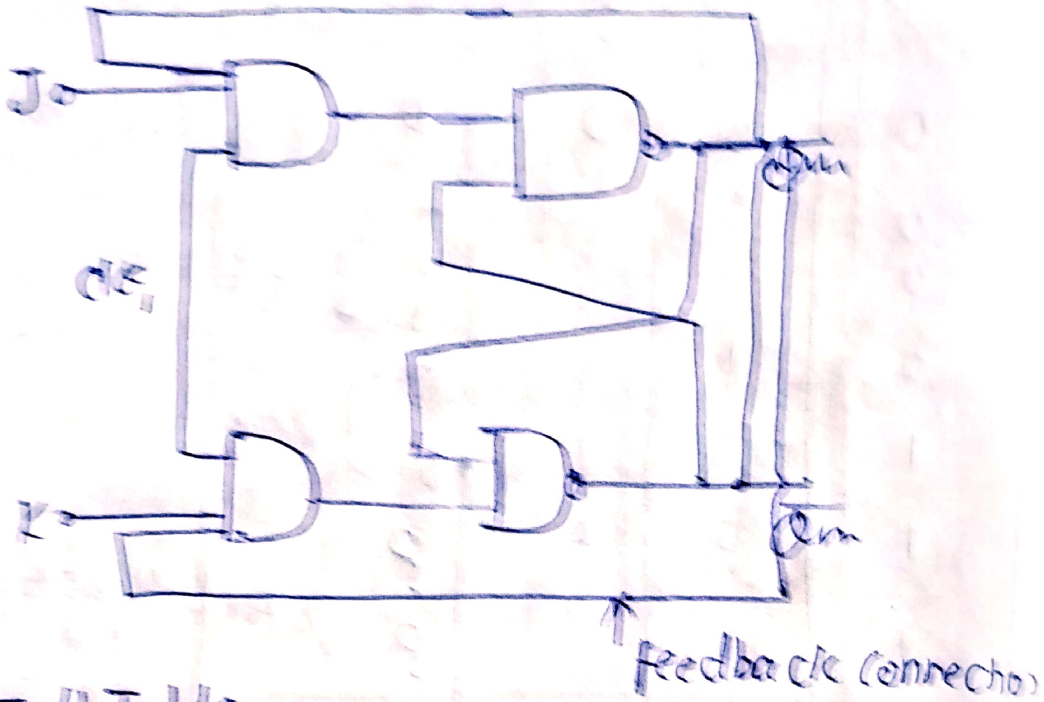
J-K flip-flop



Truth Table

J	K	Qn	Qn+1	
0	0	0	0	Qn
0	0	1	1	
0	1	0	0	
0	1	1		
1	0	0		
1	0	1		
1	1	0		
1	1	1		

+Char

Flip-Flop

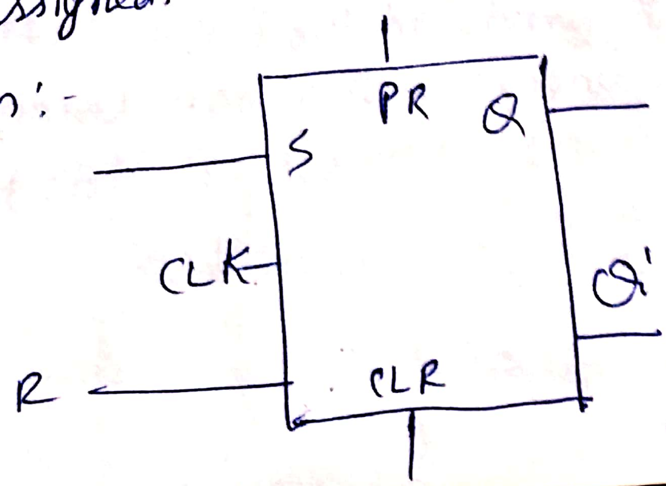
The flip-flop is a circuit that maintains a state untill directed by input to change state. A Basi flip-flop can be constructed using four NAND or four NOR gates. Flip-flop is popullarly know as the basic digital memory circuit. It has its two states as logic 1 (High) and logic 0 (low) states. A flip-flop is a sequential circuit which consist of single binary state of information or data.

Types of flip flop :-

① SR flip flop :-

In this flip-flop with the help of presecand clear when the power is switched ON, the states of the circuit keeps on changing, that is it is uncertain. It may come set ($Q=1$) or reset ($Q'=0$) state. In many applications it is desired to initially set or preset the flip-flop that is the initial state of the flip-flop that needs to be assigned.

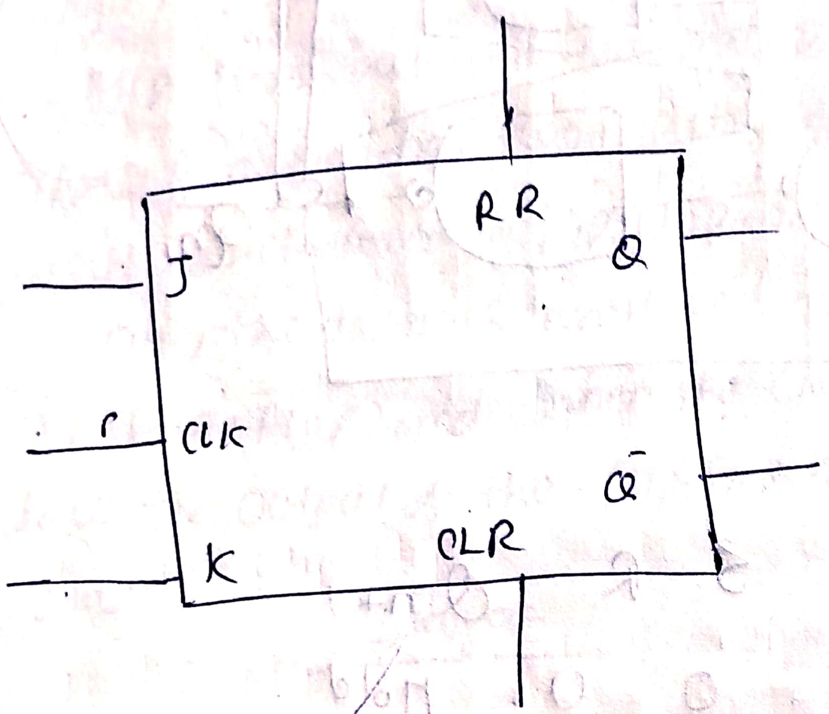
Block Diagram :-



-: J-K flip flop :-

In JK-flip-flops, The basic circtuicture/ Structure of the flip-flop which consists of Clock (CLK), clear (CLR) and preset (PR).

(Block) Diagram



It's a kind of sequential logic circuit which stores binary information in bitwise manner. It consists of two inputs and two outputs, Inputs are set(J) & Reset(K) and their corresponding outputs are Q and Q'. JK flipflop has two modes of operation which are synchronous mode & Asynchronous mode. In synchronous mode, the State will be changed with the clock(clk) signal, and in asynchronous mode, the change of state is independent from it's clock signal.

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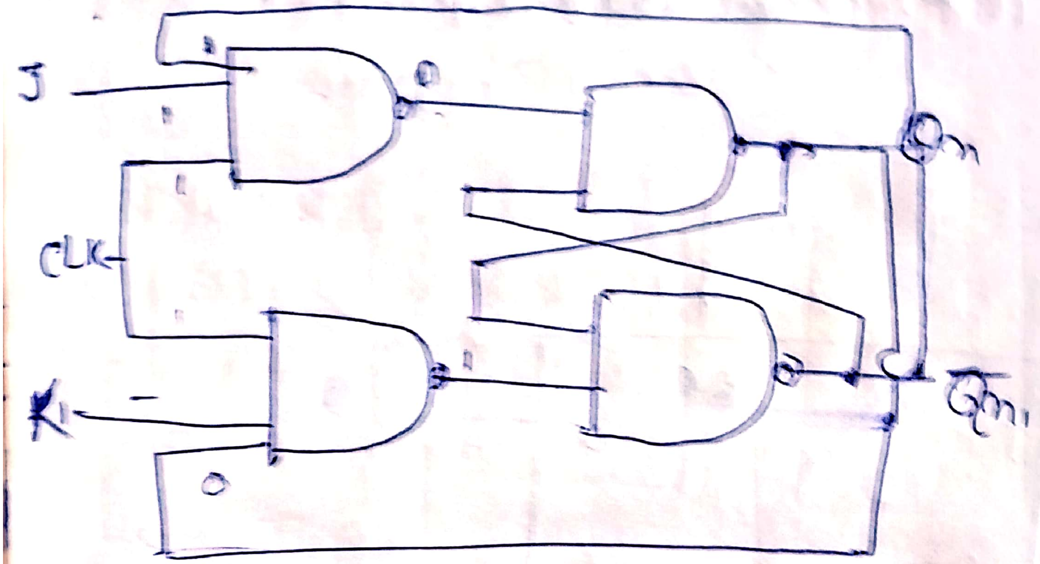
Circuit Diagram & Truth Table



1 case $Qn = 1$
2 case $\overline{Qn} = 0$
$Qn+1 = 0$

S	R	Qn+1
0	0	hold
0	1	0 reset
1	0	1 set
1	1	$\boxed{\text{invalid}}$

$\overline{Qn}$ Toggle

case2 = $Qn = 0$
case = $\overline{Qn} = 0$
$Qn+1 = 1$

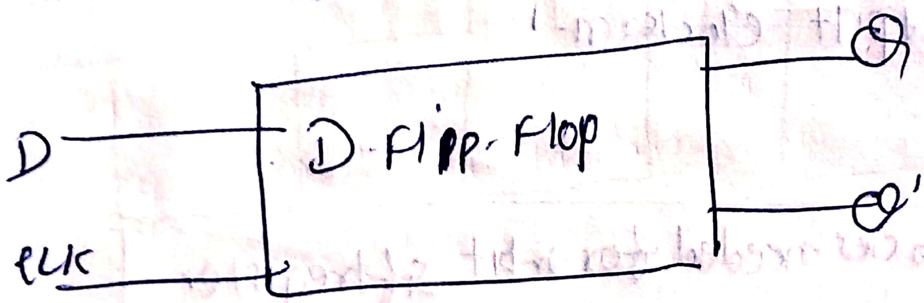
$\boxed{\text{Toggle}}$

→ Characteristic table.
Excitation table.
→ Equation.

D flip-flop

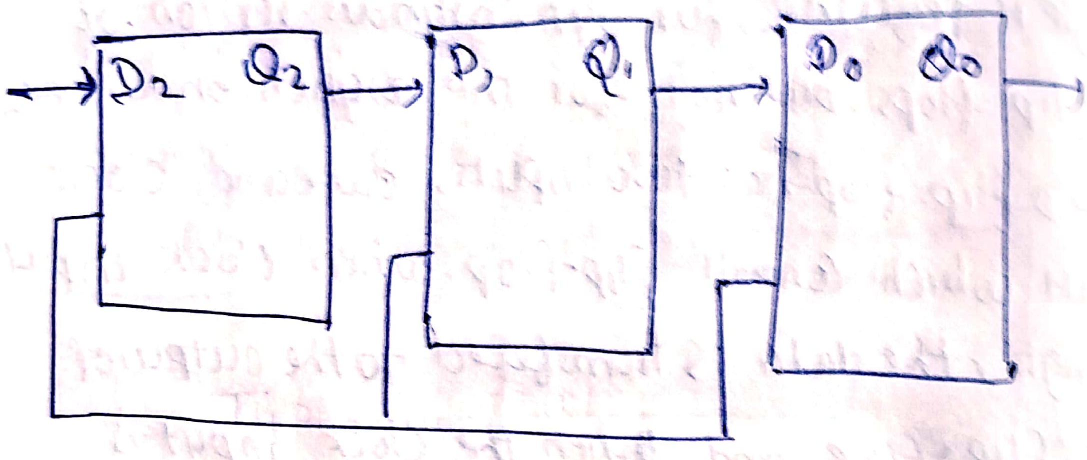
D flip-flop is an electronic devices that is known as "delay flip-flop" or "data flip-flop" which is used to store single bit of data. D flip flops are synchronous or asynchronous. The clock single is required for synchronous version of D flip flops. but not for the asynchronous one. The D flip-flop has two inputs, data and clock input which controls flip-flop. when clock input is high, the data is transfered to the output of the flip-flop and when the clock input is low, the output of the flip-flop held in previous state

Diagram



:- Shift Registers.

- Shift registers are used to implement arithmetic operations.
  e.g. Left shift, Right shift.
- Basic flip-flop used in the register is D FF.

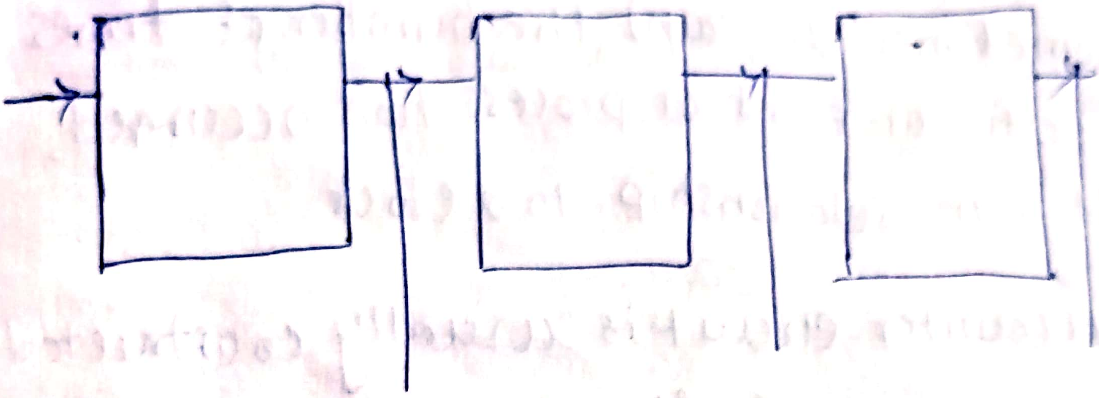


→ SISO → serial input serial out.

Loading clock – n
Output clock: n-1

Mode.	Clocks needed for n-bit shift register		
	Loading	Reading	Total
SISO	n	n-1	2n-1
SIPO	n	0	1
PISO	1	n-1	n
PIPO	1	0	1

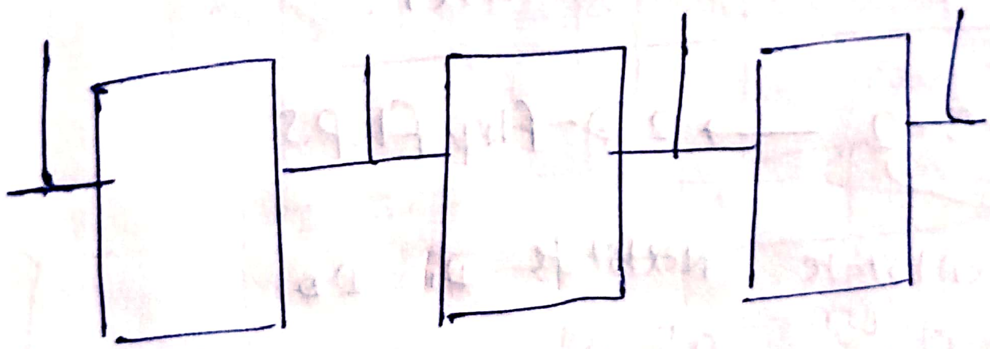
→ serial input parallel output (SIPO)



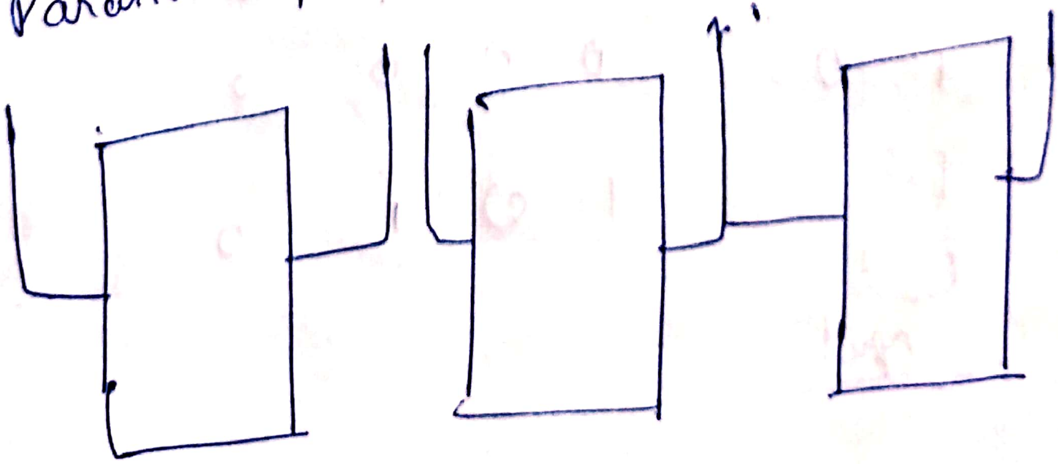
Loading clock - n

output clock - 0

→ PISO (Parallel input serial output)



→ Parallel input parallel output



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—: Counters :—

- Counter is a device that stores (and sometimes displays) the number of times a particular event or process has occurred often in relationship to a clock.

- A counter circuit is usually constructed of a number of flip-flops connected in cascade

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

—: Types of Counter :—

→ Synchronous Counter :-

0 - 1 - 3 - 2 ⟶ 2 D-flip flops

Present state Q_1 (MSB)	Present state Q_0 (LSB)	Next state Q_1^+	Next state Q_0^+	D_1	D_0
0	0	0	1	0	1
0	1	1	1	1	1
1	0	0	0	0	0
1	1	1	0	1	0

input

$D_1 =$

$\bar{Q}_1$		1
Q_1		1

$D_1 = Q_0$

$D_0 = \bar{Q}_1 \bar{Q}_0 + \bar{Q}_1 Q_0$

$D_0 = \bar{Q}_1 (\underbrace{\bar{Q}_0 + Q_0}_{1})$

$D_0 = \bar{Q}_1$