Unit - I

Overview of Electronic components and signal

Types of Electronic components

Active components:

An active component supplies energy to an electric circuit and hence has the ability to electrically control the flow of charge.

Example: Diode, BJT, FET, MOSFET

Passive components:

A passive component is an electronic component when connected in a circuit can only receive energy, which it can either dissipate, absorb or store it in an electric field or a magnetic field.

Example: Resistors, Inductors, Capacitors

Resistance :

Resistance is opposition to current flow in an electrical circuit.

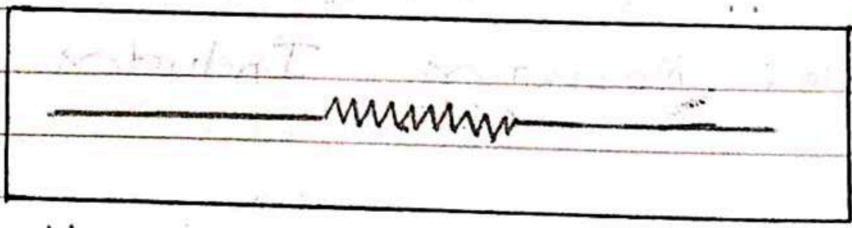
Formula $R = \frac{V}{I}$

unit ohm (Ω)

symbol Ω

Resistor :

The resistor is an electrical component with two terminal. It is one of the most important component in a circuit a it allows the user to precisely contr the amount of current and voltage in the circuit.



Applications :

1. Heating element
2. Current control
3. Amplifier circuits

Inductance:

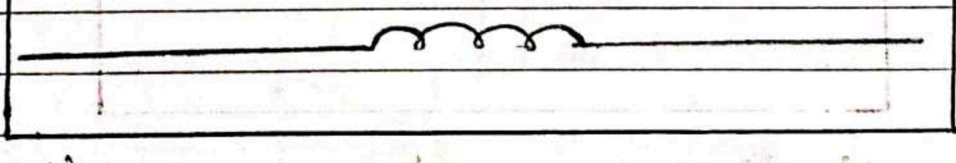
Inductance is the tendency of an electrica conductor to oppose a change in the electric current flowing through it.

Formula : $L = \frac{\phi i}{i}$

unit Henry (H)
Symbol L

Inductor:

Inductor is a two terminal component that temporarily stores energy in the form of a magnetic field. It is usually called as a coil. The main property of inductor is that it oppose any change in current. Inductor blocks AC present in DC.



Applications:
1. It is used for allowing flow of D.C.
2. It is used in filter circuits to minimize the ripple voltage.
3. It is used in sensors.
4. It is used in energy storage.

Capacitance:

Capacitance is the ability of a material object or device to store electrical charge.

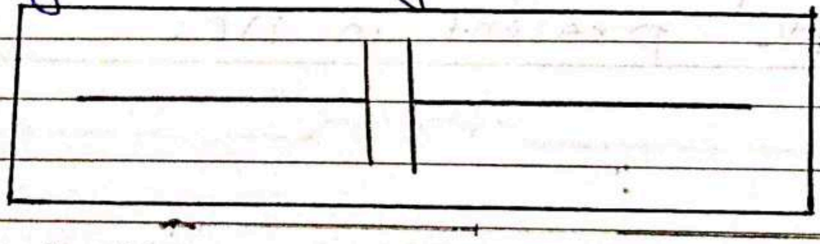
Formula $C = \frac{Q}{V}$

unit Farad

Symbol C

Capacitor:

A capacitor is a passive component that has the ability to store the ~~charge~~ energy in the form of potential difference between its plates. It resists a sudden change in voltage.



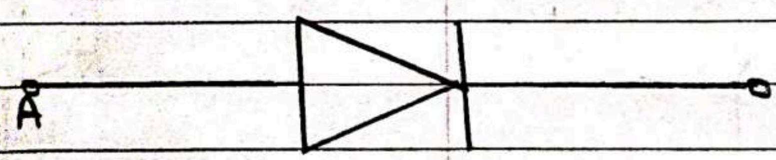
Applications

1. It opposes flow of D.C. through it.
2. It oppose any change of voltage in the circuit.
3. It removes the ripple from DC power supply.

Type of connec-tion	Resistor	Inductor	Capacitor
Series	$R = R_1 + R_2$	$L = L_1 + L_2$	$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C}$
Parallel	$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$	$\frac{1}{L} = \frac{1}{L_1} + \frac{1}{L_2}$	$C = C_1 + C_2$

Diode :

Diode is a two terminal two junction semiconductor device that acts as a one way switch for current. It allow current to flow in one direction, but restricts current from flowing in opposite direction.



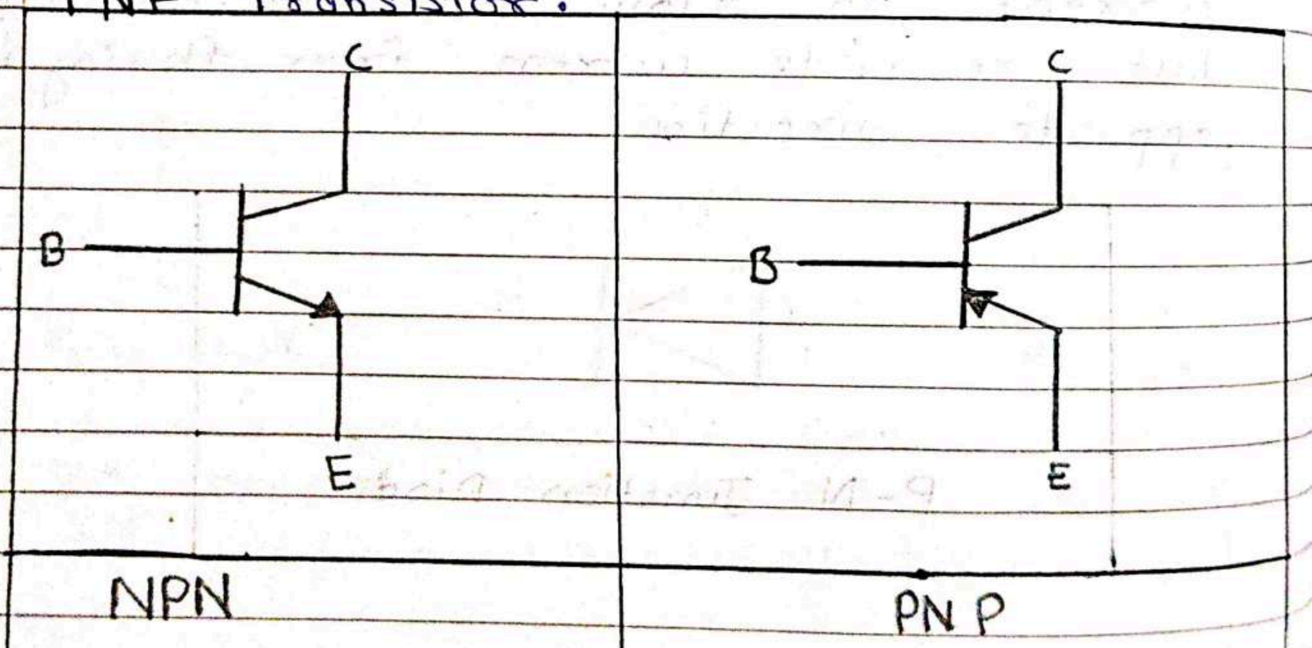
P-N Junction Diode

Diode Applications:

1. It is used to ~~convert~~ construct rectifier circuit to convert AC signals to DC signals.
2. It is used as a switch.
3. It is used to clip or clamp input signals

Transistor (BJT):

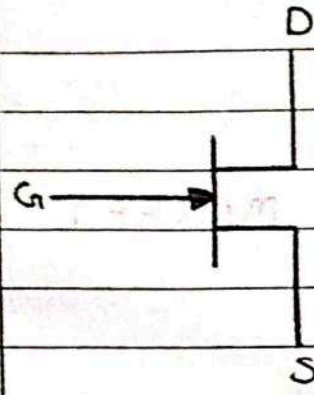
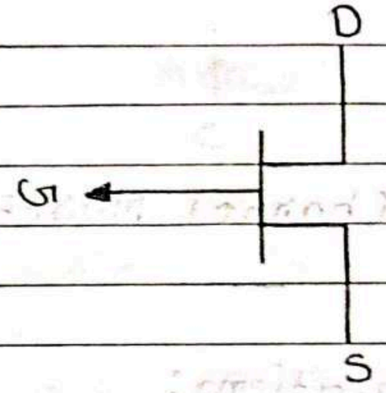
Transistor is a two junction, three region, three terminal device. Three terminals are emitter, base and collector. Two types of Transistor NPN and PNP transistor.



Applications of Transistor :

1. Amplifier
2. Logic Circuits
3. Switching Circuits
4. Wave shaping

FET (Field Effect Transistor) :

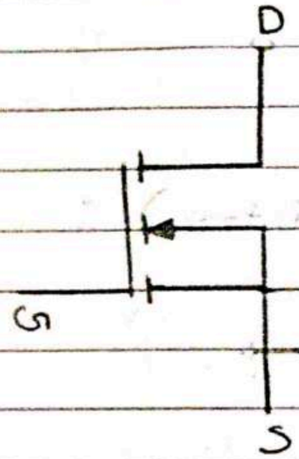
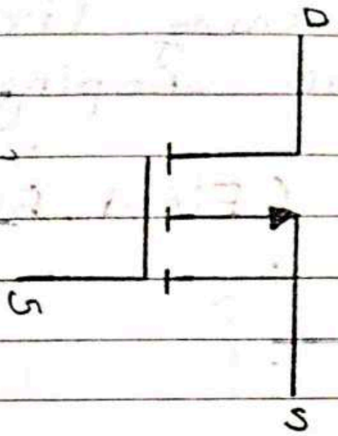
	
N - Channel	P - Channel

FET has three terminals : Drain, Source, Gat

Applications :
1. Switching circuits
2. Digital circuits
3. Memory devices
4. Oscillator

MOSFET :

Metal Oxide Semiconductor Field Effect Transistor

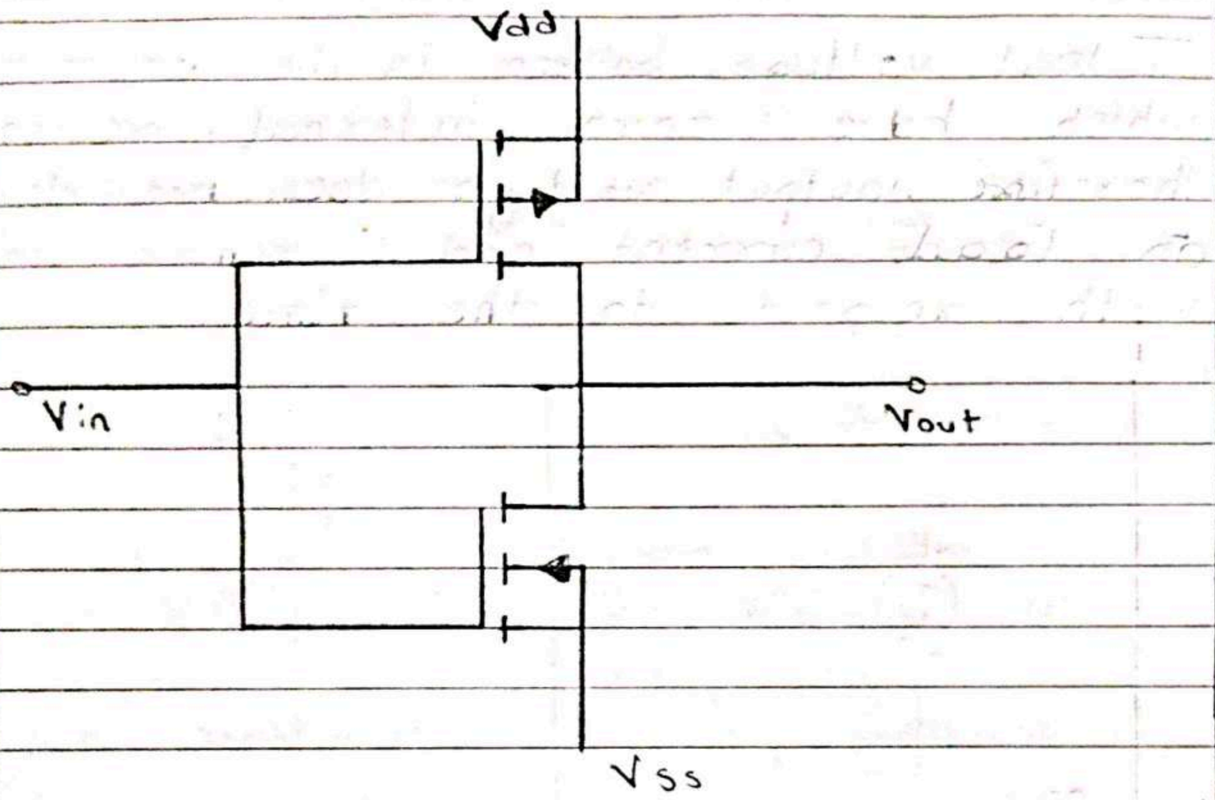
	
N - Channel MOSFET	P - Channel MOSFET

Applications:

1. High current and voltage switching.
2. AC drives
3. Inverter

CMOS :

Complementary Metal Oxide Semiconductor device



CMOS Device

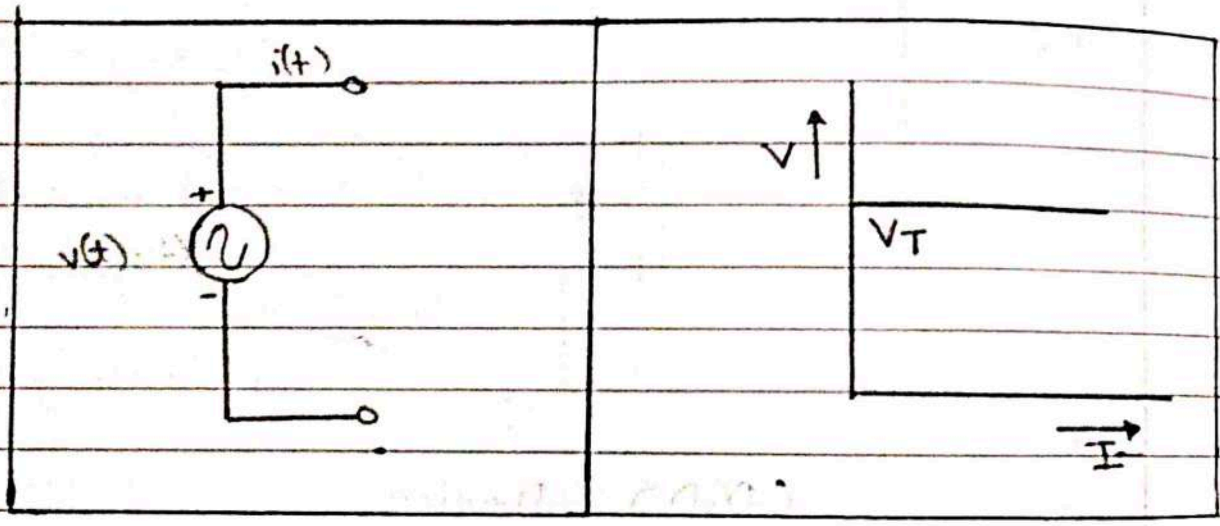
Applications :

1. Digital circuit fabrication
2. Logic gates
3. Counters
4. Memory devices.

Voltage and Current Sources

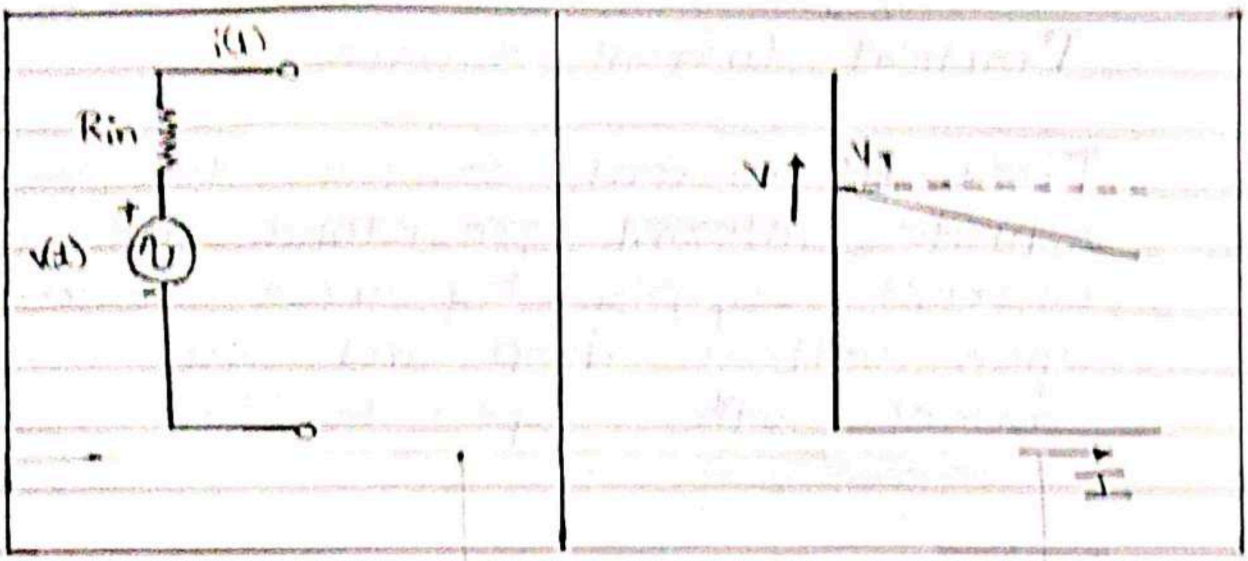
Ideal Voltage Source:

Ideal voltage source is the source which have zero internal resistance. therefore output voltage does not depend on load current and it remain constant with respect to the time.



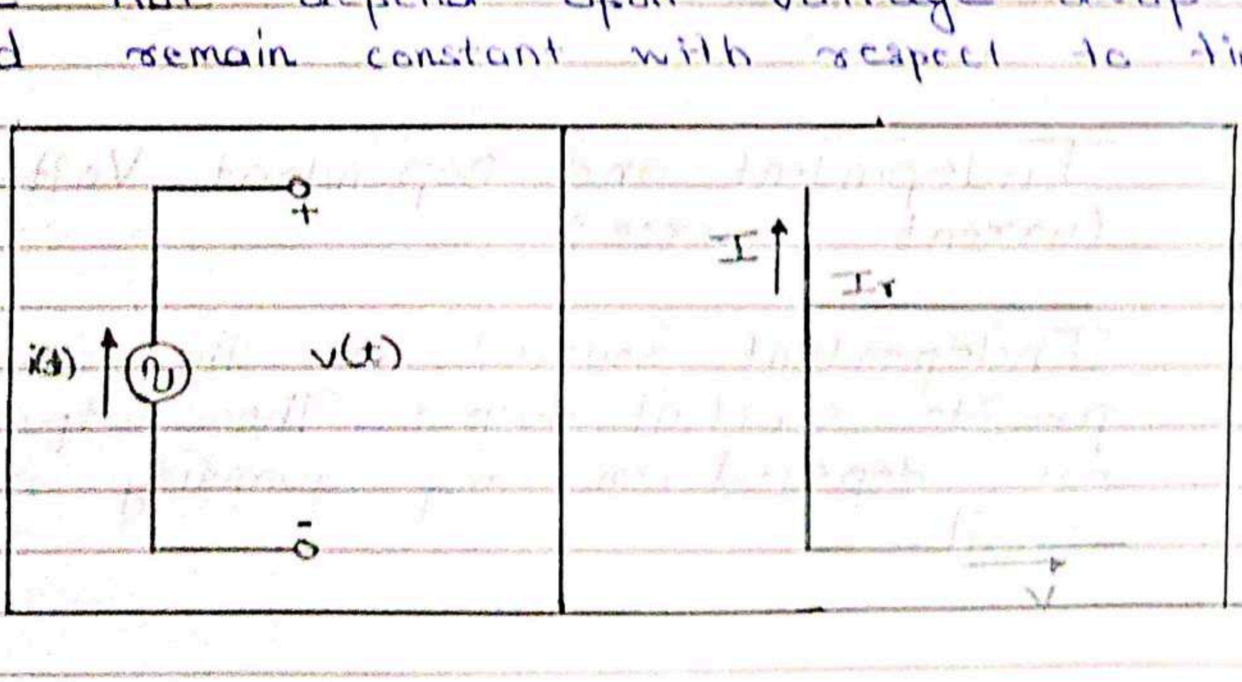
Practical Voltage Source:

Practical Voltage source are the source which have some internal resistance therefore output voltage vary with the time and load current.



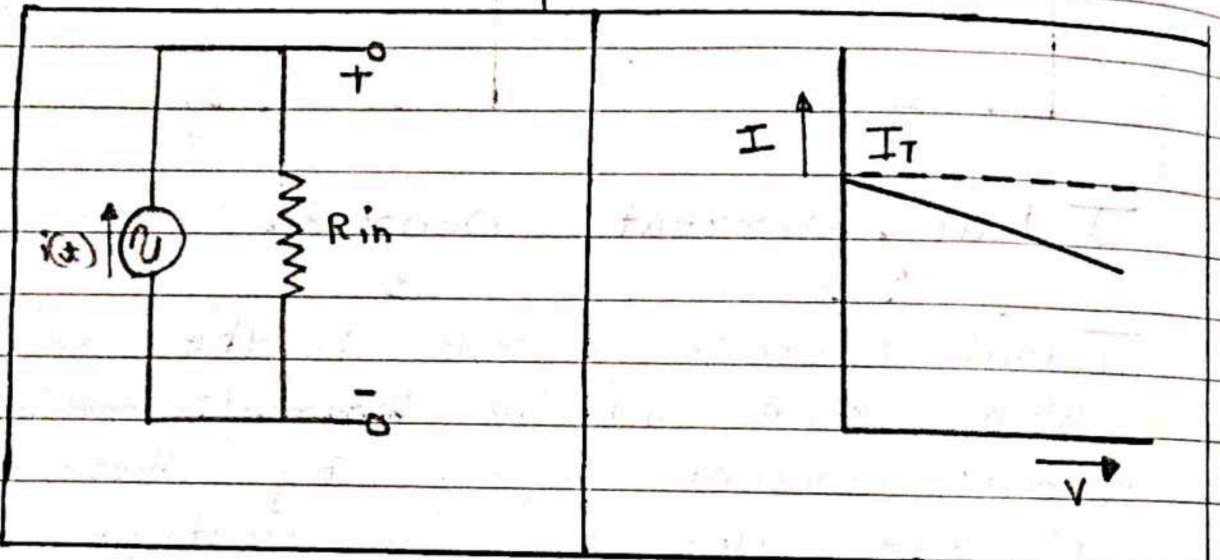
Ideal Current Source:

Ideal current source is the source which have infinite internal resistance the output current supply by these source are not depend upon voltage drop and remain constant with respect to time.



Practical Current source:

Practical current source does not have infinite internal resistance the output current supply by these sources depend upon voltage drop and does not remain constant with respect to time.

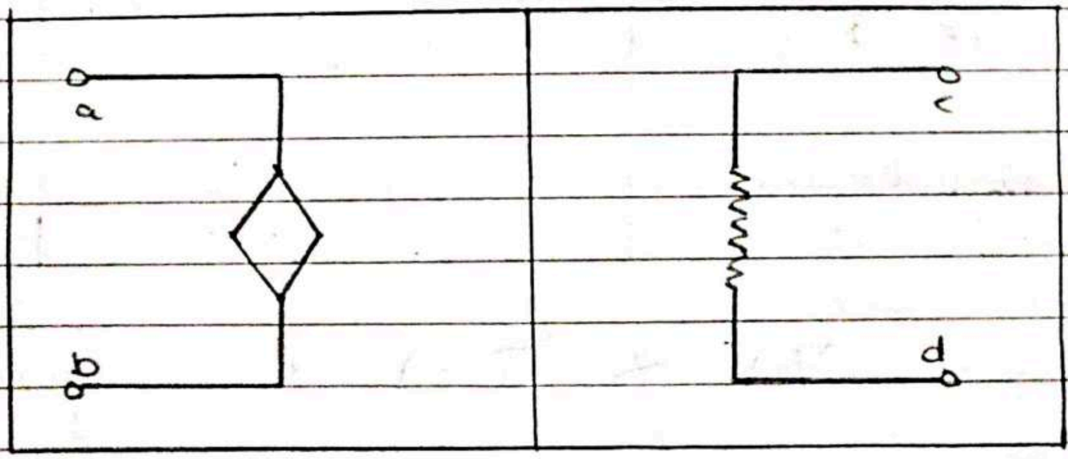


Independent and Dependent Voltage and Current source:

Independent source: are the source which provide constant output. The output does not depend on any quantity of the circuit.

Dependent Source : These are source whose output is not fixed but it depend upon voltage and current of other part of the circuit.

1. Voltage controlled Voltage Source (V.V.S.) :

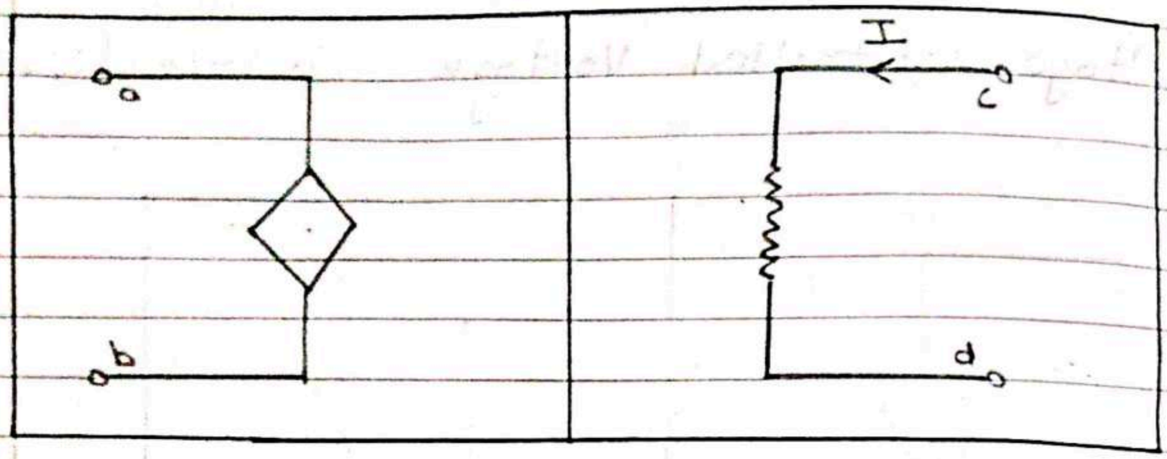


$$V_{ab} \propto V_{cd}$$
$$V_{ab} = K\, V_{cd}$$

2. Voltage controlled current source :

$$I_{ab} \propto V_{cd}$$
$$I_{ab} = \eta V_{cd}$$

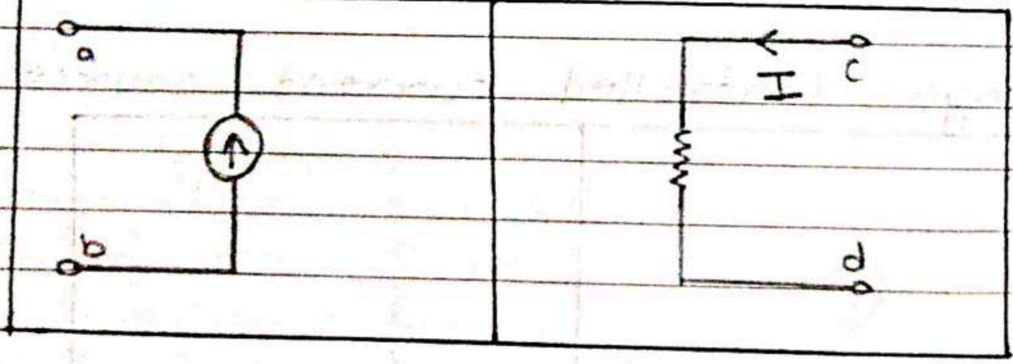
3. Current Controlled Voltage Source :



$$V_{ab} \propto I_{cd}$$

$$V_{ab} = \gamma I_{cd}$$

4. Current Controlled Current Source:



$$I_{ab} \propto I_{cd}$$
$$I_{ab} = \beta I_{cd}$$

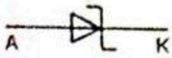
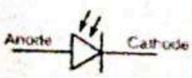
g. In communication systems, for signal demodulation i.e. detection of information signal and in computers for reset circuits diodes are used

h. To avoid D.C. saturation of inductive relay or motor, diode is connected across it.

1.2.2.5 Types of diodes

PN junction diode operation, VI characteristics and applications are depends on material used doping construction and physical dimensions. Table 1.2 shows basic three types of diodes their features and applications.

Table 1.2: Types of Diodes

Sr. No	Diode with symbol	Features	Applications
1	Zener Diode 	1 Doping concentration is very high than normal P N junction diode. 2 Normally operated in reverse biased. 3 It exhibits zener breakdown in reversed biased condition. 4 It is made up of silicon.	Zener diode is used for 1 Voltage regulation in regulated D C power supply. 2 Meter protection circuits 3 Spike guard circuits.
2	Light Emitted Diode (LED) 	1 Special semiconductor materials are used such as GaAs, GaAsP, GaP, SiC. 2 When this diode is forward biased then it emits light. Wavelength i.e. color of emitted light depends on doping material. 3 Emission of light energy due to injection of charge carrier is a basic working principle of LED 4 It is available in various sizes. 5 Emitted light intensity is proportional to current flowing through it.	LED is used for 1 Power indicator for various electrical and electronics appliances. 2 In electronic appliances as a display device. 3 Constructing seven segment and matrix display. 4 Opto coupler, remote control 5 Light sources for distance measurement and other similar instruments. 6 Optical switching and communication systems.
3	Photo Diode 	1 Special semiconductor material is used. 2 It covert light intensity into current. 3 It is normally operated in reverse biased.	Photo diode is used for 1 Light sensing. 2 Burglar alarm. 3 Opto coupler. 4 Auto flash camera.

1.2.3 Transistors

A bipolar junction transistor (BJT) is basically a silicon or germanium crystal having two P-N junctions formed by sandwiching either P-type or N-type semiconductor between a pair of opposite types. BJT is normally called a transistor. It is capable of amplifying weak signals. Thus the current in transistor (or BJT) flows due to positive as well as negative polarity charge carriers. Therefore, a transistor (BJT) is called a bipolar device.

1.2.7 Comparison between Passive and Active Components

Table 1.6 Represents the comparison in brief between passive and active components on major aspects.

Table 1.6: Comparison between passive and active components

Sr. No.	Criteria	Passive Components	Active Components
1.	Nature of source	Passive components utilize power or energy from the circuit.	Active components deliver or control power or energy to the circuit.
2.	Examples	Resistor, Capacitor, Inductor etc.	Diodes, BJT, FET, Integrated circuits etc.
3.	Power Gain	They are incapable of providing power gain.	They are capable of providing power gain.
4.	Flow of current	Passive components cannot control the flow of the current.	Active components can control the flow of current.
5.	Requirement of external source	They do not require any external source for the operations.	They require an external source for the operations.
6.	Nature of energy	Passive components are energy acceptor.	Active components are energy donor.

Activities

1. After learning Topic No. 1.1 and 1.2 of this unit, student should try to identify and prepare list on various gadgets available at home using active and passive components.
2. Student shall refer data book to know about active and passive components with their major specifications and prepare a presentation with two components each of different varieties.

Classifications of Electronic Components

Solved Problems

Example 1.2.1: In BJT three terminals currents are $I_1 = 100$ mA. $I_2 = 93$ mA and $I_3 = 7$ mA. Identify terminal names.

Solution: BJT has three terminals: 1) Emitter 2) Base 3) Collector. Out of the three terminal currents, emitter current is always largest.

As in given data, I_1 is largest so it current flowing through Emitter terminal.

$$I_E = I_C + I_B$$
$$100 \text{ mA} = 93 \text{ mA} + 7 \text{ mA}$$

In BJT, base current is smallest. So I_3 current is flowing through Base terminal.
Therefore I_2 current is flowing through Collector.

Unit - II

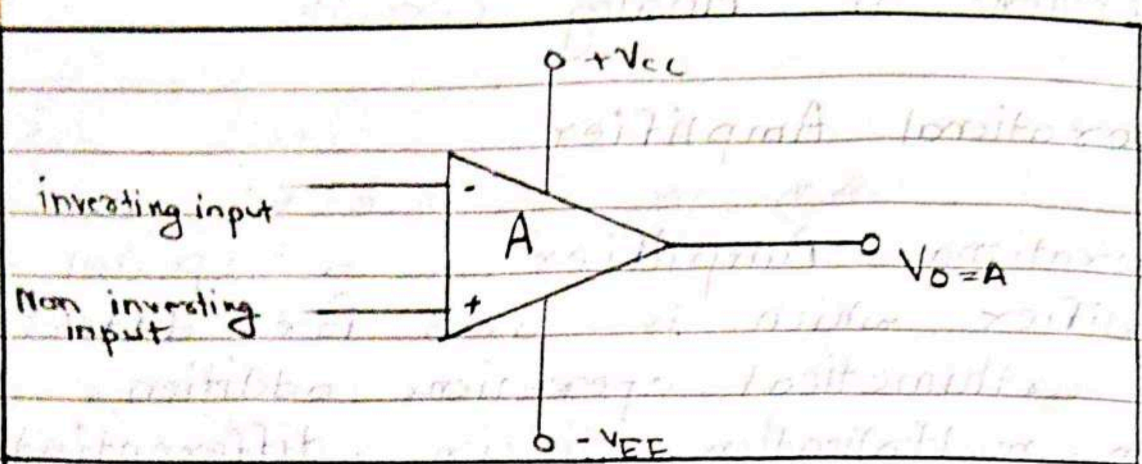
Overview of Analog Circuits

Operational Amplifier

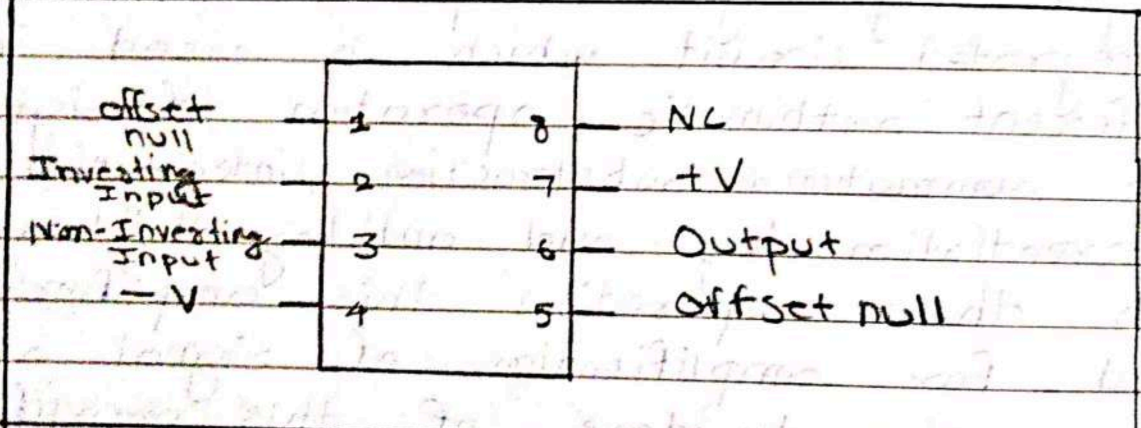
Operational Amplifier is a special type of amplifier which is used for different type of arthimetical operations addition, substraction, multiplication, division, differentiation, integration, log and anti log.

Operational Amplifier is direct coupled multi staged high gain amplifier. It is a Integrated circuit which is used in different arthimetic operation of signal like summation, substraction, integration, differentiation, log and anti log. Along with these operations this amplifier is used for amplification of signal also, the main advantage of this amplifier is that it can process beat signal by rejecting the noise with the help of differential arrangment. This amplifier can be operated in negative feedback as well as positive feedback arrangment.

This ampifirer circuit is found in integrated circuit I.C. form. The most common IC is 741 and this IC has 8 pins.



Symbol of Op-Amp



Pin out diagram of IC 741

1. Pin 1 : Offset Null :

This pin is used for balancing or zeroing the offset voltage of The IC.

2. Pin 2 : Inverting Input :

Inverting Input is a pin of IC the signal input at that pin out of phase with the output of amplifier.

3. Pin 3 : Non - Inverting Input :

The Non - Inverting Input is a pin the signal input at that pin is in phase with output of amplifier.

4. Pin 4 : $-V_{EE}$:

Pin no 4 is $-V_{EE}$ supply this supply is used for operating the circuit. Normally $-15\,V$ is applied.

5. Pin 5 : Offset Null :

This pin is used for balancing or zeroing the offset voltage.

6. Pin 6: Output:

The output of OP-AMP is available at this pin.

7. Pin 7: $+V_{cc}$:

Positive supply is given to this pin for operating the circuit. Normally +15 V is applied.

8. Pin 8:

This pin is not connected.

** Properties of Ideal Operational Amplifier:

1. Input Impedance is infinite ($Z_i = \infty$).
2. Output Impedance is zero ($Z_o = 0$).
3. It has infinite Voltage gain ($A_v = \infty$).
4. It has infinite Bandwidth.

5. Common Mode Rejection Ratio is Infinite.

6. It produces zero output voltage when $V_1 = V_2$

7. The open loop gain must be infinite

$$A_v = \infty$$

8. Infinite slew rate

9. The characteristics of circuit must not change with temperature.

10. Output must be zero if input is zero.

OP - AMP Parameters :

1. Input Offset Voltage : is defined as the amount of voltage that must be applied between the two input terminals of the OP - AMP to obtain 0 volts at the output when no input is given.

2. Output offset Voltage : It is the output voltage of the OP - AMP when the input terminals are grounded. To minimize it offset null pins are used.

3. Bandwidth : The bandwidth is defined as the difference between the frequency limits of the amplifier.

4. Slew rate: It is defined as the delay in output after applying input.

$$\text{Slew rate} = \frac{dV_o}{dt}$$

5. Common Mode Rejection Ratio (C.M.R.R.):

It is the ratio of differential gain Ad to common mode A_{cm}.

$$CMRR = \frac{A_d}{A_{cm}}$$

6. Impedance: It is measure of circuit opposition to AC or DC. Combination of resistance + reactance represented by Z

7. Open loop Voltage Gain: of amplifier is the ratio of output signal to the input signal in open loop conditions.

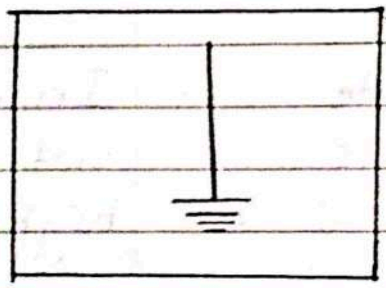
$$A_i = \frac{V_o}{V_i}$$

Difference Between Ideal OP-AMP and Practical OP-AMP

	Ideal OP-AMP	Practical OP-AMP
1	It has infinite voltage gain so that it can amplify input signal of any amplitude.	It's voltage is not infinite but typically high of the order of 10^5.
2	It has infinite input resistance.	Input Impedance is not infinite but very high of the order 10^6.
3	It has zero output resistance.	output resistance is not zero but very low of the order of few Ω.
4	It has infinite CMRR.	CMRR is not infinite but typically value ranges between 50 to 100 dB.
5	It has zero output voltage when input voltage is zero.	It is not able to give zero at output when input is zero.

Virtual Ground:

In OP-AMP the term virtual ground means that the voltage at that particular node is almost equal to ground voltage (0V). It is not physically connected to ground.



OP-AMP configurations

The operational amplifier can be configured in two mode one is open loop and second is the close loop mode.

Open loop:

The open loop configuration is a configuration in which there is no connection between output and the input.

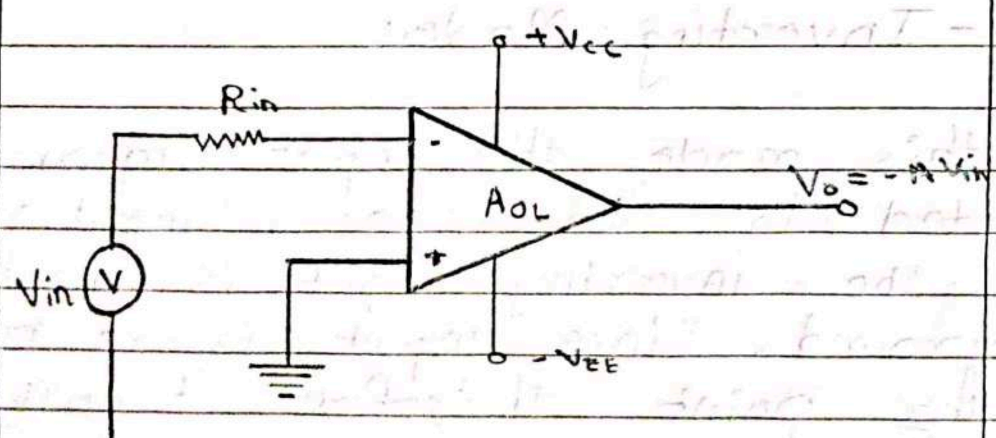
In this configuration the performance of the amplifier is quite low and, It is very sensitive to undesired noise and signal. Mostly output depends upon input parameter and circuit condition.

Therefore this configuration is not used practically.

Modes in Open loop Configuration

Following are three modes in open loop configuration

1. Inverting Amplifier / Mode :



Open loop Inverting OP-AMP

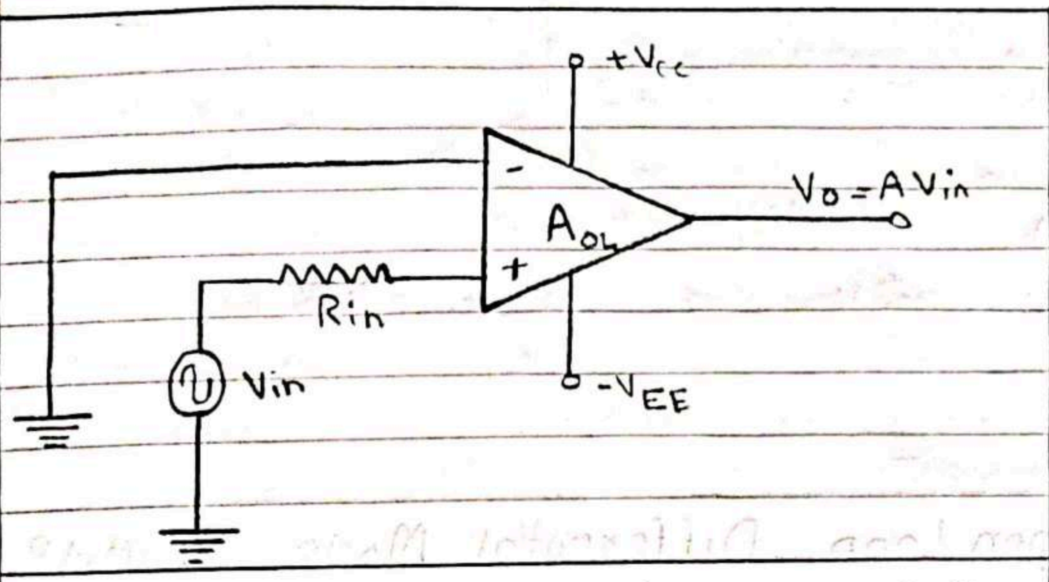
In this mode the input signal is connected to inverting input of OP-AMP while the non-inverting input is connected to ground. The output of amplifier in this mode is 180° out of phase (180°) with respect to the input signal. Therefore output is represented by -ve sign.

$$V_o = -A(V_{in})$$

where
V_{in} = input signal
A = gain
V_o = Amplified output

2. Non-Inverting Mode:

In this mode the input signal is connected to non-inverting input of OP-AMP while the inverting input is connected to ground. Since input is at non-inverting point therefore it called non-inverting mode.



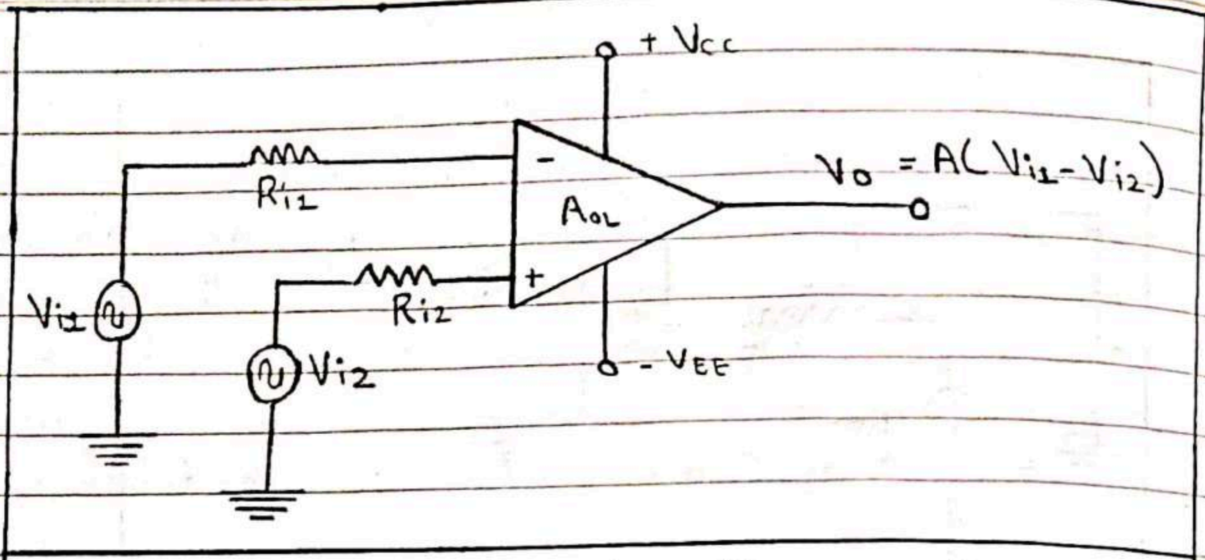
Openloop Non-Inverting OP-AMP

Since in this mode the input is given to non-inverting ~~mode~~ point therefore output is in phase with the input signal.

$$V_0 = A V_{in}$$

3. Differential Mode:

In this mode input signal ~~of~~ of different amplitude is given to both input point (Inverting and Non-Inverting). It amplifies the difference between the two input signal. therefore it is called differential amplifier.



Open Loop Differential Mode OP-AMP

Therefore in differential Mode difference of two signal amplifies while the common signal is rejected out.

$$V_o = A(V_{i1} - V_{i2})$$

Limitations of Open Loop configuration:

1. In this configuration the maximum value of output is limited by magnitude of DC supply Voltage ($+V_{cc}$ and $-V_{EE}$) otherwise if limit is crossed the output is clipped.

2. In open loop configuration there is no provision of feed back therefore undesired noise and distortion commonly occured at the output.

3. The gain of the amplifier is not stable due to variation in atmospheric conditions.

4. In open loop configuration the band width of amplifier is very small therefore this configuration has limited application.

Close Loop:

In close loop configuration some part of the output is feedback and connected to input through proper feedback circuit. Operational Amplifier are used with degenrative or negative feedback which reduces gain of operational amplifier but greatly increases the stablity of circuit.

Types of feedback in close loop

There are two type of feedback in close loop:

1. Negative feedback:

Negative feedback is the type of feedback system in which the feedback portion of output are out of phase with the input signal therefore actual input to amplifier is difference of input signal and feedback signal. This type of feedback improve the stablity of system as well as provide noise free output. This feedback is mostly used in amplifier circuit.

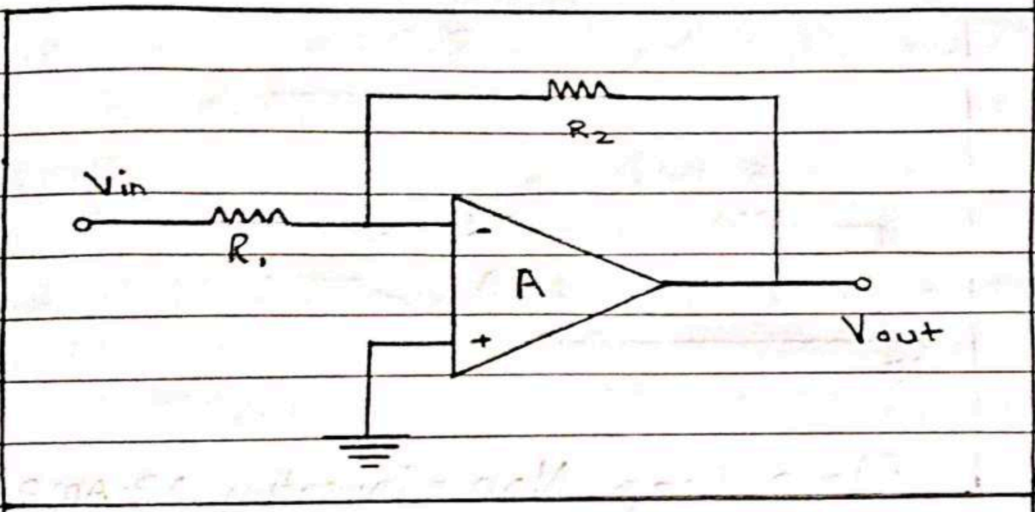
2. Positive feedback:

Positive feedback is a type of feedback in which input and feedback part of the output are in phase therefore they are additive and actual input to amplifier increase. This type of feedback is normally used.

Different Mode in Close Loop:

Close loop circuits can be of the inverting configuration or non-inverting configuration.

1. Inverting Mode:



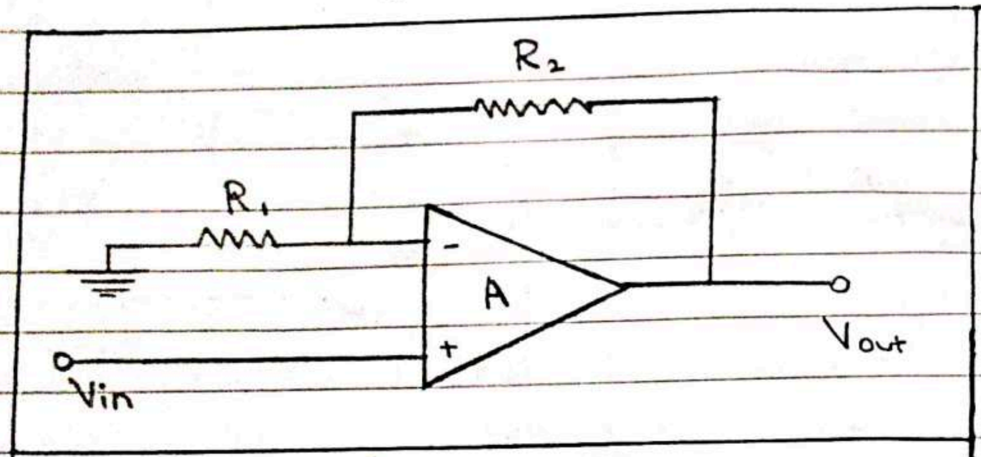
Close loop Inverting OP-AMP

In this mode the input signal is connected to inverting input and feedback is also given to it by resistor R_2. The non-inverting input is connected to ground. The output signal is 180° out of phase with the input signal.

Gain of Inverting OP-AMP in close loop configuration

$$A = \frac{-R_2}{R_1}$$

2. Non-Inverting Mode:



Close Loop Non-Inverting OP-AMP

The input signal Vin is applied directly to the non-inverting input of the operational amplifier. Feedback is provided back to inverting input of operational Amplifier. The input signal, output signal and feedback signal are all in phase.

$$A = \frac{R_2}{R_1} + 1$$

Difference Between Open loop and Close loop configuration

S.no	Open Loop	Close Loop
1	Any change in output has no effect on the input.	Changes in output, affects the input.
2.	Feedback element is absent.	Feedback element is present.
3.	It is inaccurate and unreliable.	Highly accurate and reliable.
4.	Generally more stable	These are less stable
5.	Small bandwidth	Large bandwidth
6.	Very sensitive in nature	Less sensitive to disturbances
7.	Simple design	Complex design
8.	Cheap	Costly
9.	Error detection is not present	Error detection is present

Advantages of Negative feedback

1. Gain of the amplifier decreases.

2. Gain stablity increases

3. Noise and distortion decreases

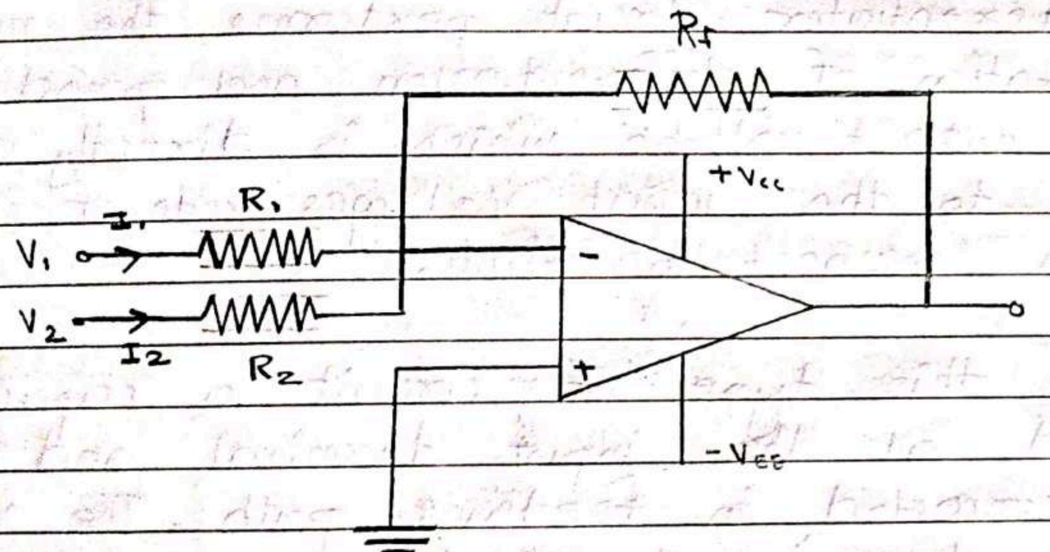
4. Increase in bandwidth.

Applications of OP-AMP

OP-AMP is a high gain direct coupled amplifier with feature of externally voltage gain controlled, it finds many applications in signal processing and conducting applications. Due to its low cost, high performance and versatile nature it is used in many analog circuit

1. OP-AMP as adder:

A summing Amplifier or adder circuit is used for adding two or more input signals. ~~for~~ Basically it is a inverting amplifier. Input is given to inverting input terminal and non-inverting terminal is connected to ground. This circuit can be used to add AC or DC signal. This circuit provides output voltage equal to the algebraic sum of two or more input voltage each multiplied by constant gain factor.



OP-AMP as adder circuit

$$V_O = -\frac{R_f}{R_i}(V_1 + V_2)$$

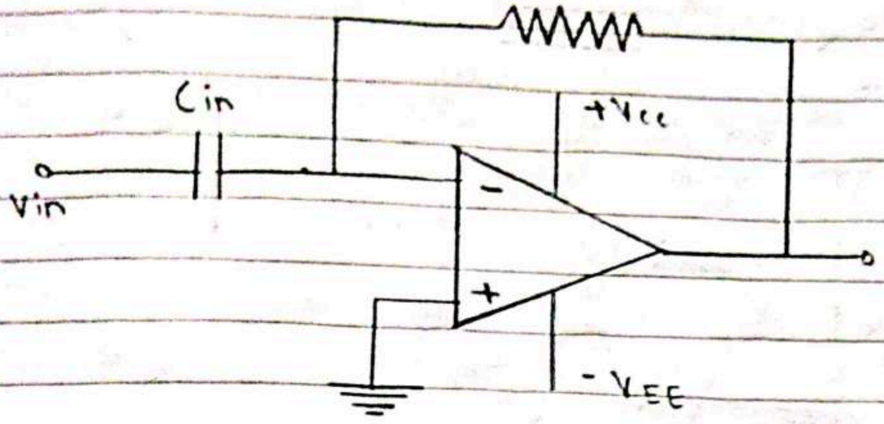
2. OP-AMP as a Differentiator

Differentiator is a circuit which is used for differentiation of input signal. Basically it is a inverting amplifier input is given to inverting terminal and output becomes the differential form of input. The differentiator circuit performs the mathematical operation of differentiation and produces an output voltage which is directly proportional to the input voltages rate of change with respect to time.

In this type of circuit a capacitor is used at the input terminal and resistance is connected in feedback path. The value of RC decide rate of differentiation of Input signal.

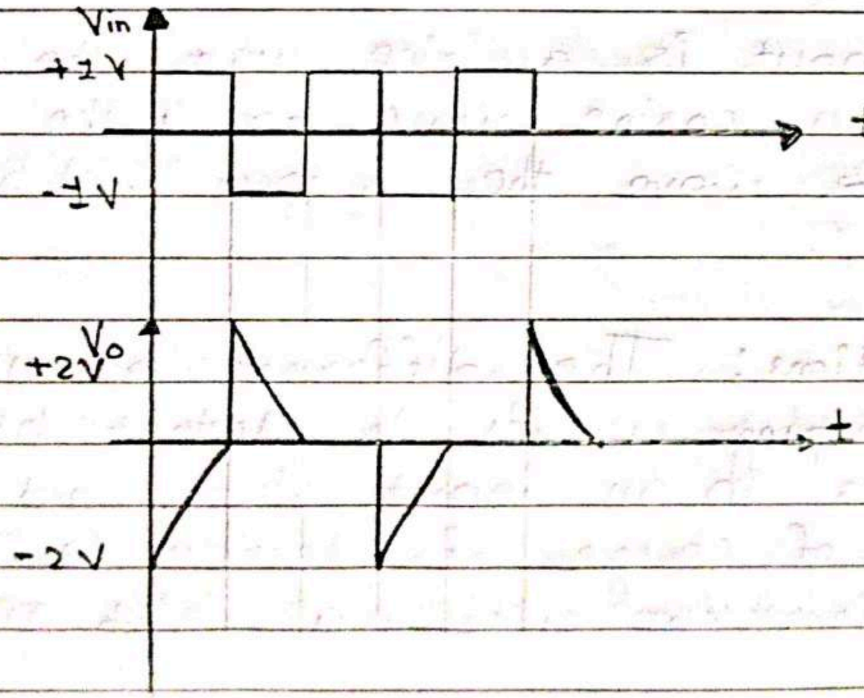
$$V_O = -R_F C_1 \frac{dV_{in}}{dt}$$

The -ve sign indicates a 180° phase shift of output waveform V_o with respect to the input signal.

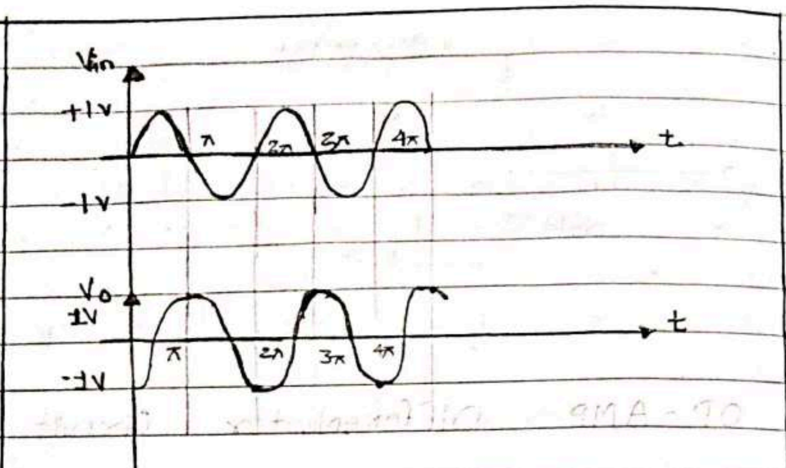


OP-AMP Differentiator Circuit

Input output Waveform :



Ideal output Waveform using square wave



Ideal Output Waveform using sine wave

If Input is a sine wave the output will be a cosine wave or if the input is a square wave the output will be trigger pulse.

Applications: The differentiator used in wave shaping circuits to detect high frequency components in an input signal and also as a rate of change of detector in FM modulators. The differentiator acts as a high pass filter.

3. OP - AMP
Intro:
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Output:
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Circuit

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3. OP - AMP as Integrator

Intro :

The OP-AMP base integrator is a circuit which is used for integrating the input signal the circuit consist of a capacitor in feedback path and a resistance at the input terminal! Basically it is a inverting amplifier therefore the input signal is given to inverting terminal and non-inverting terminal connected to ground.

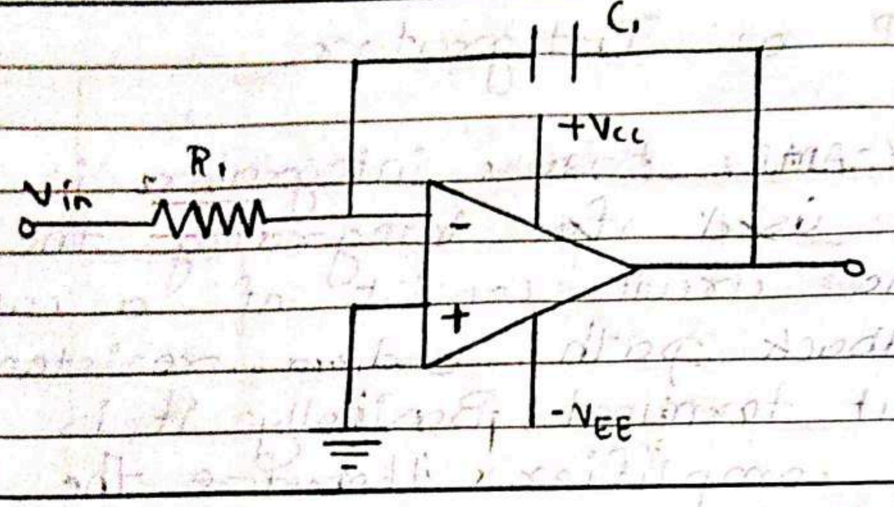
Output :

The integrating circuit performs the mathematical operation of ~~differential~~ integration and output is integration of input voltage with respect to time.

Circuit Information :

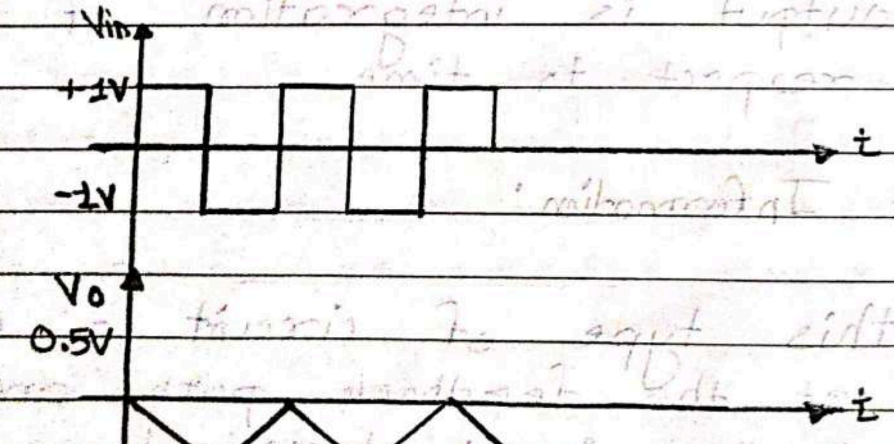
In this type of circuit a capacitor is used at the feedback path and a resistance at the input terminal.

$$V_0 = \frac{-1}{R_1 C_f} \int_0^t V_{in}\, dt + C$$

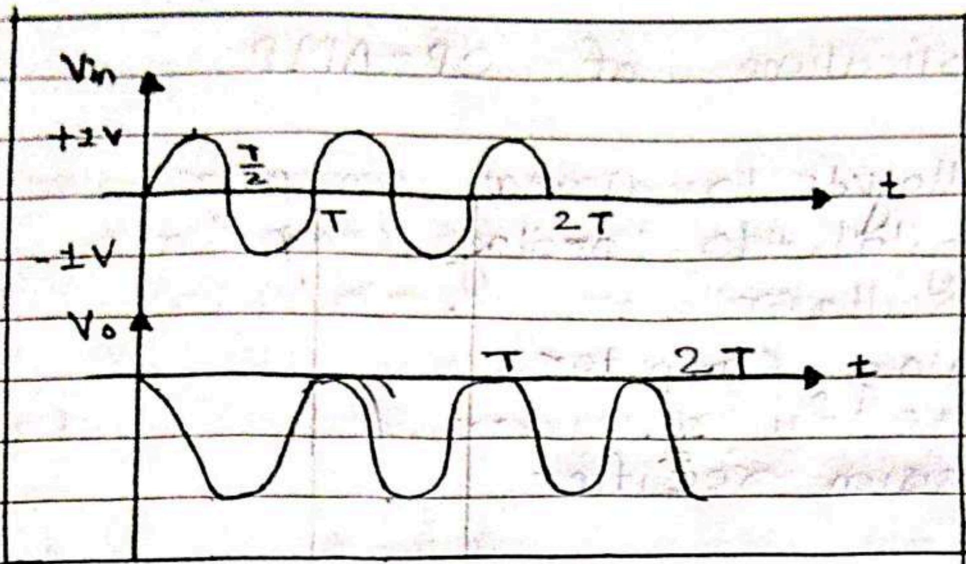


OP-AMP Integrator Circuit

Input Output Waveform



Ideal Output waveform using square wave



Ideal output waveform using sine wave

If input is sine wave the output is will be cosine wave or if the input is a square wave the output will be the triangular wave.

Applications:

1. Integrator is mostly used in Analog to digital convertor (ADC).

2. Wave shaping circuit

3. analog computers.

Applications of OP-AMP

1. Voltage to current convertor
2. Digital to analog convertor
3. Oscillator
4. Analog computer
5. Active filter
6. Precision rectifier.

3 ~~J-k flip flop~~

Boolean Algebra laws

1. Commutative law

$$A + B = B + A$$
$$A \cdot B = B \cdot A$$

2. Associative law

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

3. Distributive law

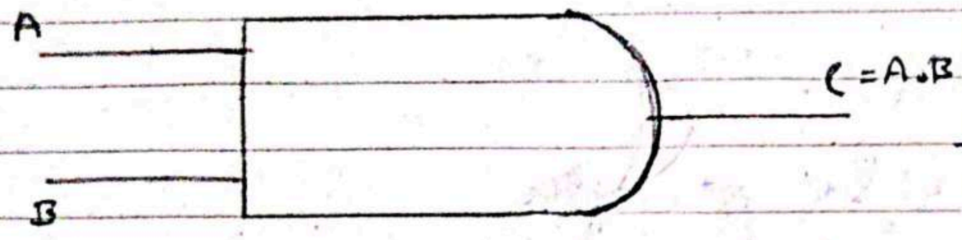
$$A + (B \cdot C) = (A + B) \cdot (A + C)$$
$$A \cdot (B + C) = (A \cdot B) + (A \cdot C)$$

4. De Morgan's theorem

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

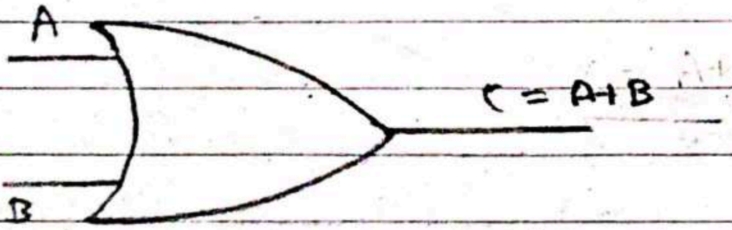
Basic logic gates

① AND Gate



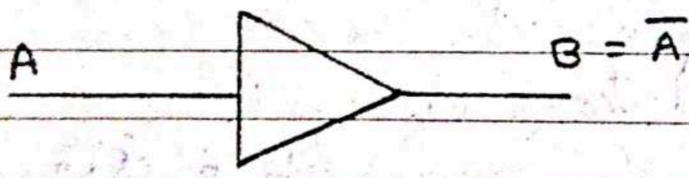
A	B	C
0	0	0
0	1	0
1	0	0
1	1	1

② OR Gate



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

③ NOT Gate

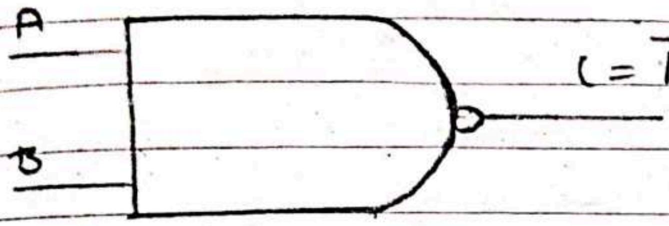


A	B
0	1
1	0

Date:
P. No:

Universal logic Gates

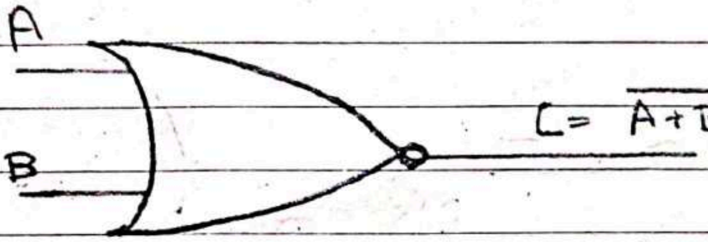
① ~~Nan~~ NAND Gate



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

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

② NOR Gate

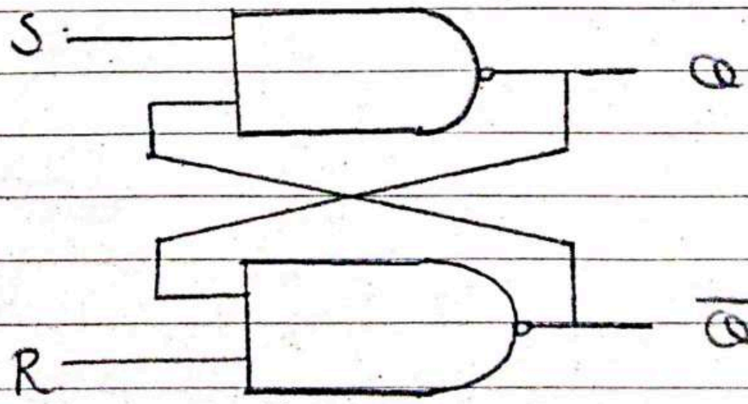


$C = \overline{A + B}$

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

Flip Flop

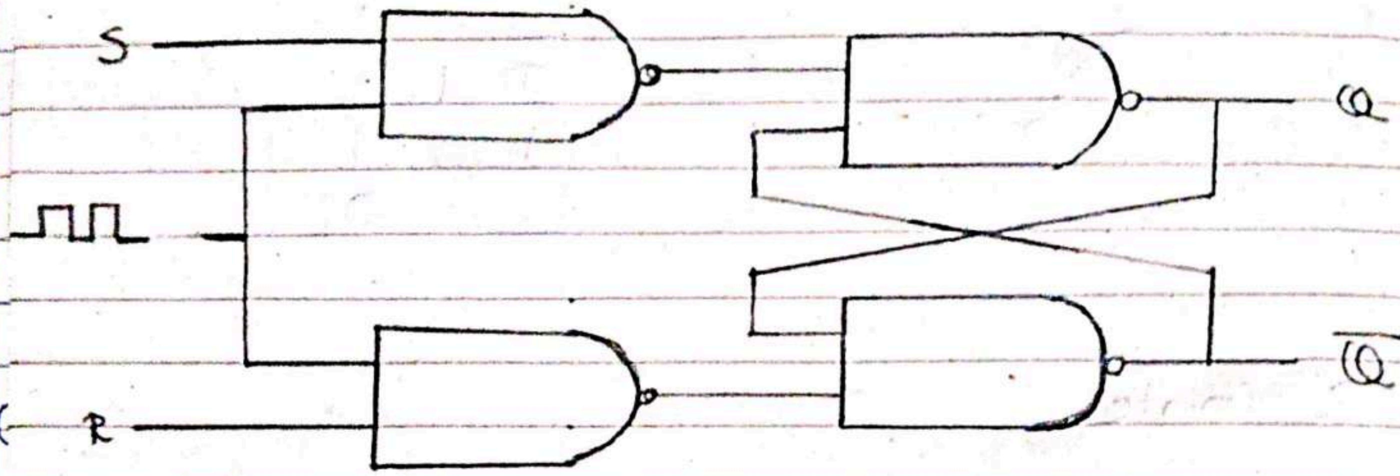
① SR latch



S	R	Q	$\overline{Q}$	Mode
0	0	-	-	Invalid
0	1	1	0	SET
1	0	0	1	RESET
1	1			No chang

Date:
P. No:

② Clocked SR flip-flop



Clock	S	R	Q	$\overline{Q}$	
1	0	0			No change
1	1	0	1	0	SET
1	0	1	0	1	RESET
1	1	1			Invalid

SR

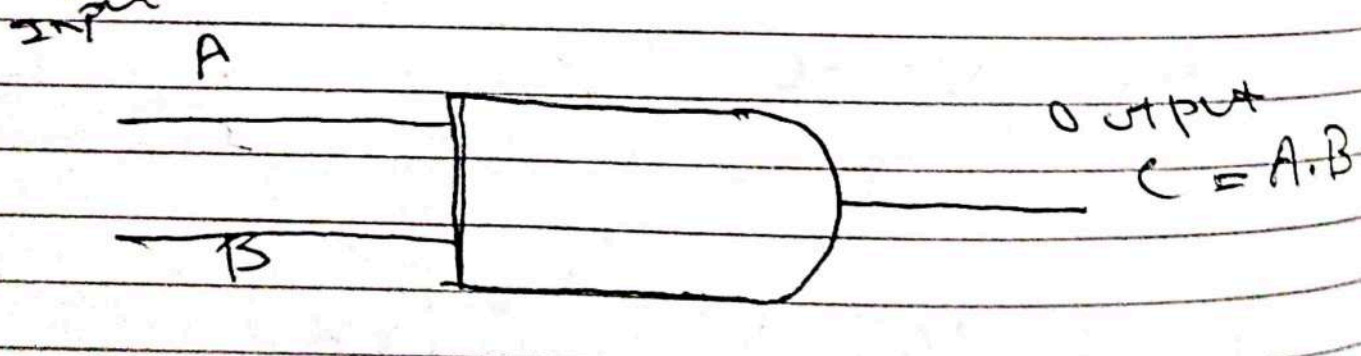
$$H = \frac{I^2 R t}{4.2}$$

$$H = 0.238\, I^2 R t \text{ Calories}$$

23/4/24 FEEE

logic Gate: logic gate are basic building blocks of digital electronics for design and fabrication of logic digital circuit.

① AND gate: The output of AND gate is high if all inputs of are high Otherwise output is low. Basically, it is single output and multiple input gate.



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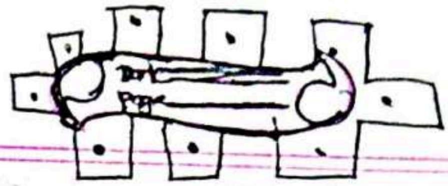
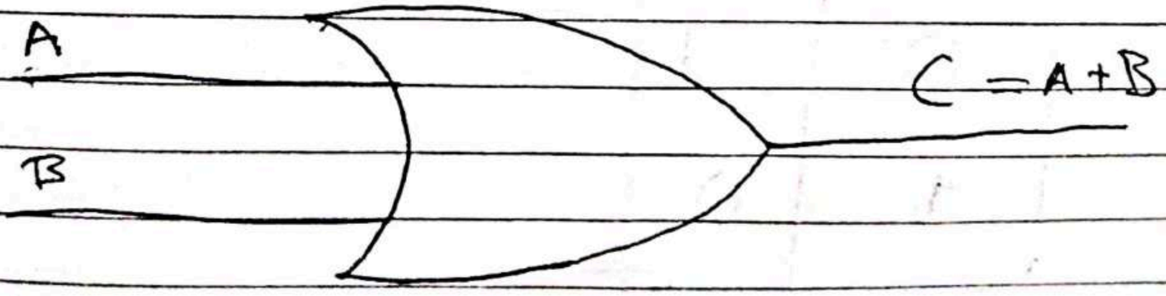


Truth Table

Input		Output
A	B	C = A.B
0	0	0
0	1	0
1	0	0
1	1	1

② OR gate: This is multiple input single output gate. If any one input ~~is high output~~ or more than one input are high then output is high. This is a multiple input and single output logical gate. If any one input or more than one inputs are high then output become high.

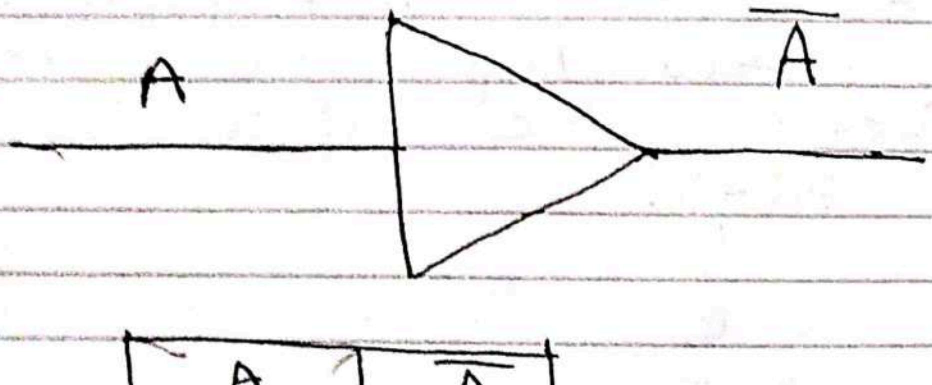
If all inputs are low then output become low.



Truth Table

Input		Output
A	B	C = A+B
0	0	0
0	1	1
1	0	1
1	1	1

NOT Gate: This is single input and single output gate the output is invert of Input means if input is low output become High if input is high it becomes low



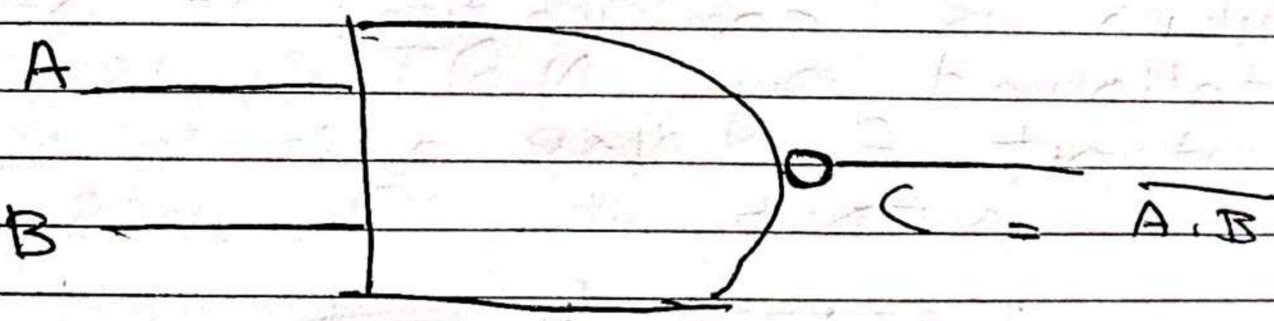
A	$\overline{A}$
0	1
1	0

All the above three gates are called basic logic gate of digital electronics.

Universal logic Gate:

Universal logic gates are the gates using these gates any basic logic gates and any digital circuit can be designed. Therefore these gates are called Universal gate. There are two universal gate ~~Nan~~ NAND Gate and NOR Gate

① NAND Gate

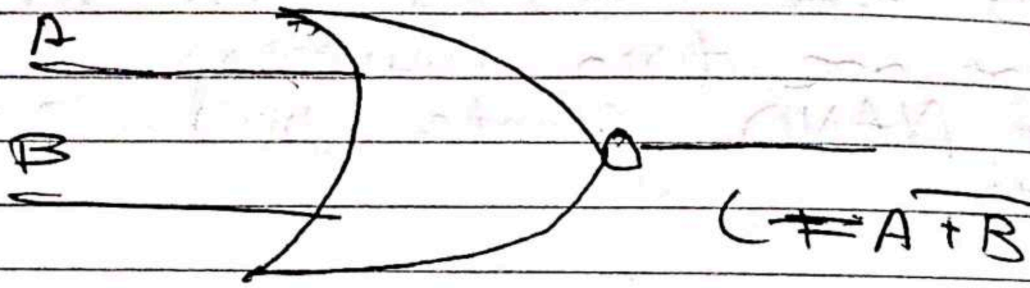


Nand gate is a universal gate in which output is inverted of ~~and~~ AND gate output. It is combination ~~AND~~ AND gate and NOT gate.

Truth table NAND Gate

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

② NOR Gate :-



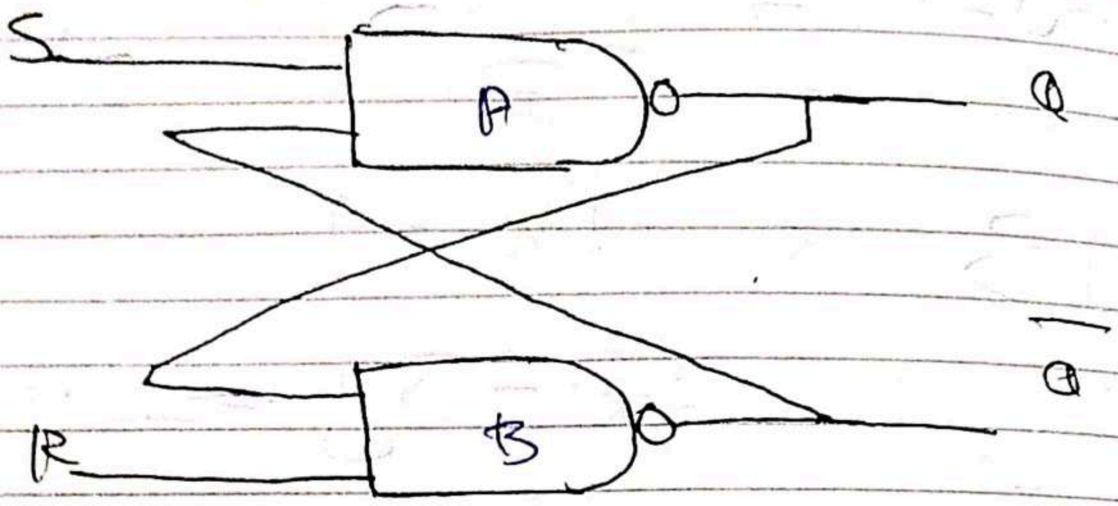
NOR Gate is a universal Gate which is combination of OR Gate followed by NOT Gate. The output of NOR gate is Inverted of output of OR Gate

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

Sequencial Circuit

flip-flop

1. RS flip flop (Asynchronus) (latch)



It is unclocked flip. It has two Input SET and RESET and two output Q and $\bar{Q}$.
Simple RS (SR) flip-flop is unclocked sequencial circuit it is also called latch circuit. this flip flop has two input (S) SET and other is R (RESET). Similarly it has two output Q and $\bar{Q}$. In normal condition Q and $\bar{Q}$ are complementary to each other. The detail of the output stating with respect to Input as given below:

① If $S=0$ and $R=1$.
In this state the output of NAND Gate A Become ~~1~~, ~~and~~ $Q=1$ and the output of NAND gate become 0, $\overline{Q}=0$
This state is called SET condition because $Q=1$.

When
② ~~If~~ $S=1$ and $R=0$,
~~In~~ this state the output of NAND gate B become 1, $Q=1$ and it ~~makes~~ feedback to NAND gate A, therefore output of NAND gate A become 0, $Q=0$.
This condition is called RESET Condition.

③ If both input $S=R=1$,
Then the output remain Unchanged as in previous condition.

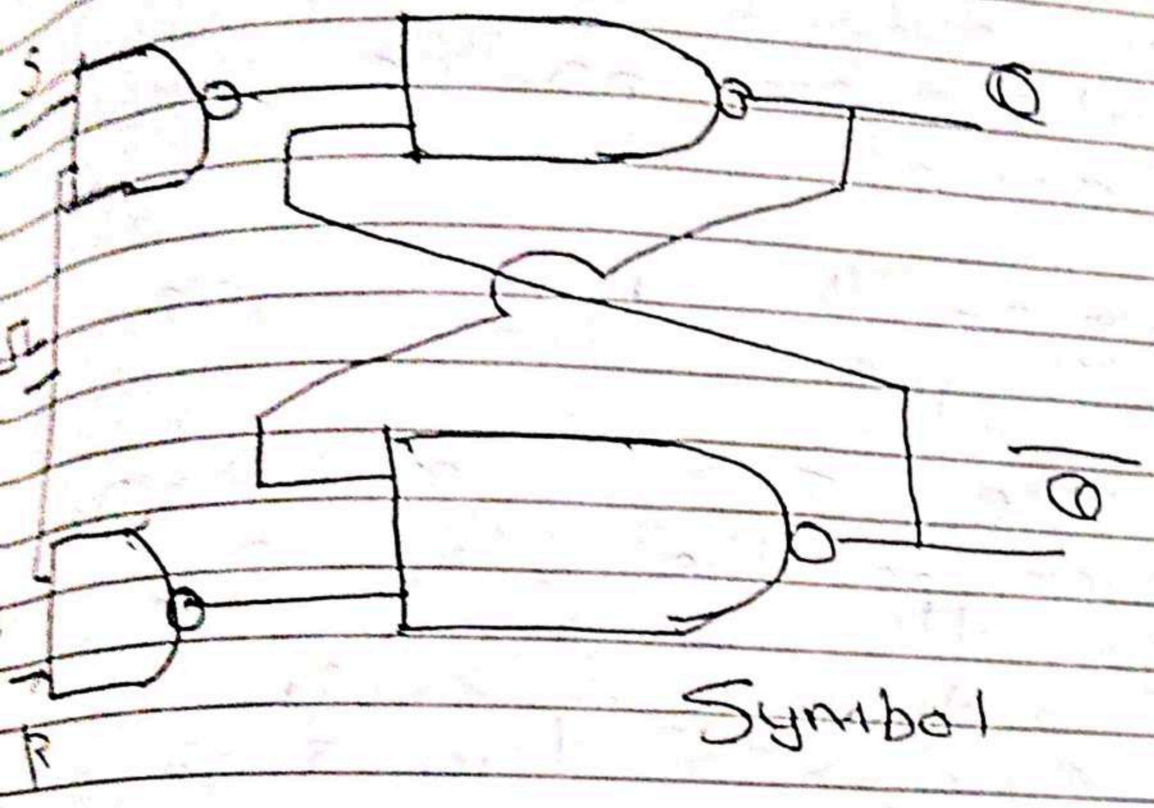
④ If $S=R=0$. In this condition the output is undefined and this condition is called Invalid condition

Truth Table

S	R	Q	$\overline{Q}$	
0	0	undefined		
0	1	1	0	SET
1	0	0	1	RESET
1	1	No change		

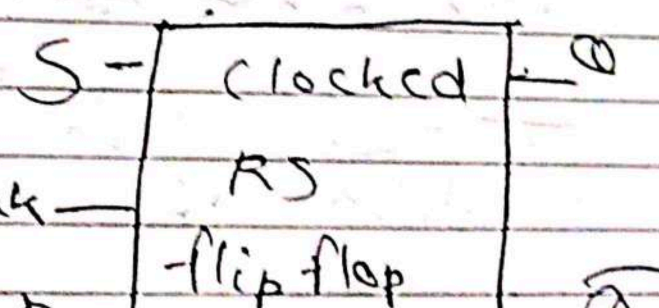
② ~~RS~~ Clocked RS flip-flop (Synchronus)

The Basic RS latch is ~~connect~~ a asynchronus flip flop, therefore output change at any time due to absence of clock. To controlling the change in the output and make it synchronise a clock pulse is added in the circuit and this type of flip-flop is called Clocked R-S flipflop. In clocked RS flip output change only when the active clock pulse occur



Symbol

Block dig



In this Clock R-S flipflop circuit the active clock pulse is positive therefore effect of the input and the output will take place whenever positive clock pulse occurs.

Following are the detail for Input Output status:

① let the $S = 1$ and $R = 0$, whenever positive Clock pulse Occurs it makes final Output $Q = 1$ and This is called SET condition of flip flop

② If $S = 0$ and $R = 1$ the whenever active clock pulse occur it makes $Q = 0$ and $\overline{Q} = 1$ this is called RESET Condition of flip flop.

③ If $S = R = 0$ In this condition whenever Clock pulse occur there is no change in the output, the previous value retain at the output side.

(4) If $R = S = 1$ In this condition whenever clock pulse occurs the value of Q and $\bar{Q}$ become same and it called undefined condition.

Truth Table

Clk	S	R	Q	$\bar{Q}$	
1	1	0	1	0	SET
1	0	1	0	1	RESET
1	0	0	No change		No change
1	1	1	Invalid		Undefined

Counters :

Counter is a sequencial circuit used for counting clock signal or input signal. Counters are used in Digital electronics for counting purpose. they can count specific event happening in the circuit.

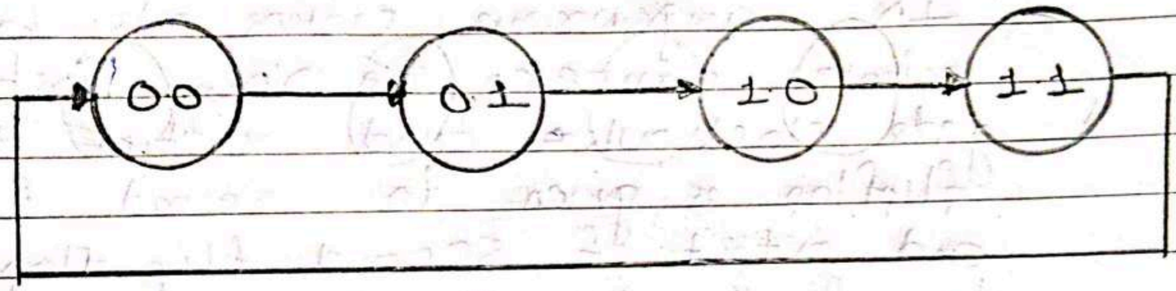
Counters are designed using flip flops if any counter has n number of Flip-Flip then it can count up to 2^n state of input pulse. Each of the counts of a counter is called state. for example a 2-bit counter ~~require~~ requires two flip flop and the number of states are 4.

Modulus of counter :

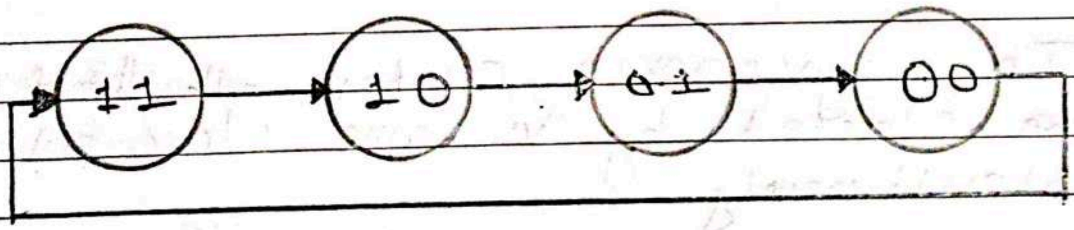
The number of states which the counter passes before reaching the original state is ~~also~~ called modulus of counter. The modulus of N bit counter is 2^N. A two bit counter is also called a modulus or mod 4 counter.

Date :
P. No. :

State Digram of 2 bit UP counter and 2 bit down counter.



State Digram of 2-bit Up counter



State digram of 2-bit Down counter

Types of Counters

① Asynchronus counters (Ripple counter)
② Synchronus : Counters (Parallel Counter)

In asynchronus canters also known as ripple canters, the only first flip flop gets clock pulse and output to thee flipflop is given to second flip flop and output of second flip flop is given to third flip flop as clock pulse and so on.

The main drawback of these canters is their low speed.

In synchronus canters all the flipflop are clocked by the same clock pulse simultaneously.

These are faster than Asynchrous counters.

Date :
P. No. :

Ripple counter

Ripple counter is a cascade arrangement of flip-flops where the output of one flip flop drives the clock input of the following flipflop. The number of flip flop in the cascaded arrangement depends upon the number of different logic states that it goes through before it repeats ~~the~~ the sequence a parameter known as the modulus of the counter.

Features of flip flop:

1. It is an asynchronous counter.

2. Different flip-flops are used with a different clock pulse.

3. All flip flops are used in toggle mode.

4. Only one flip flop is applied with an external clock pulse and another flip flop clock is obtained from the output of the previous flip-flop.

1|5|24

FEEE

Counter:

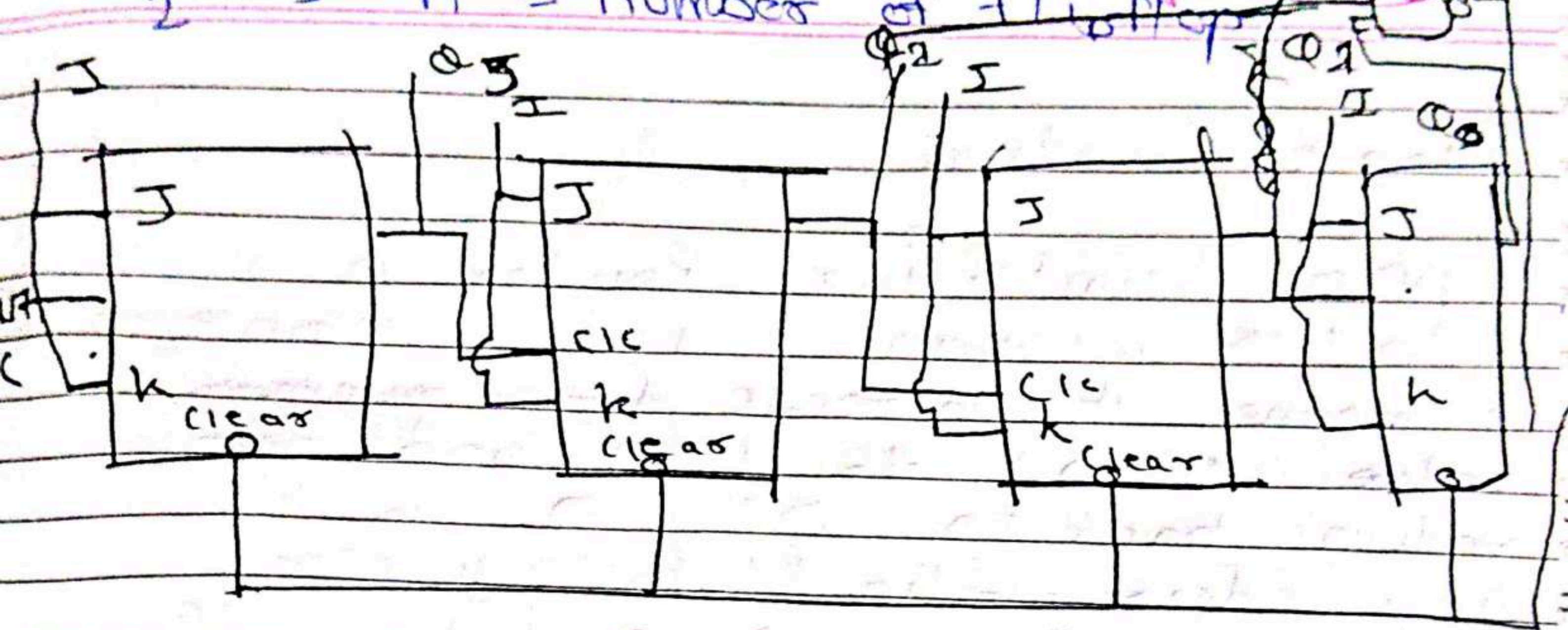
Decade Counter (MOD 10 Counter):
Decade counter is a Mod-10 counter
It count 10-state at a time
[From (0 to 9)]. or realisation of
this counter require four-flip
flop because 10 is not in
multiple of 2^n ~~less~~ next 2^n state
is 16 therefore for Mod-10
counter four flipflops are
required. In this counter
counting is progress from 0 to 9
and return back to 0 again
Therefore state from 10 to
15 must be skipped.

Truth table

Clock	Q_3	Q_2	Q_1	Q_0
1	0	0	0	0
	0	0	0	1
	0	0	1	0
	0	0	1	1
	0	1	0	0
	0	1	0	1
	0	1	1	0
	0	1	1	1
	1	0	0	0

Number of state a counter can hold

2^n = n = number of flip flop



Initially the output of all four flip-flop (Q_0, Q_1, Q_2, Q_3) are at state 0, 0, 0, 0. As soon as first clock occurs the output Q_0 become one and other are at 0 in this way clock is continuously input to flip flop first and output progress from 0000 to ~~00~~ 1001 if 1001 is the last state in mod 10 After that as soon as next clock occurs output of flip flop Q_3 and Q_2 input through reset circuit and this circuit clear all the flip flop at state 0, 0, 0, 0,

1	0	0	1
1	0	1	0

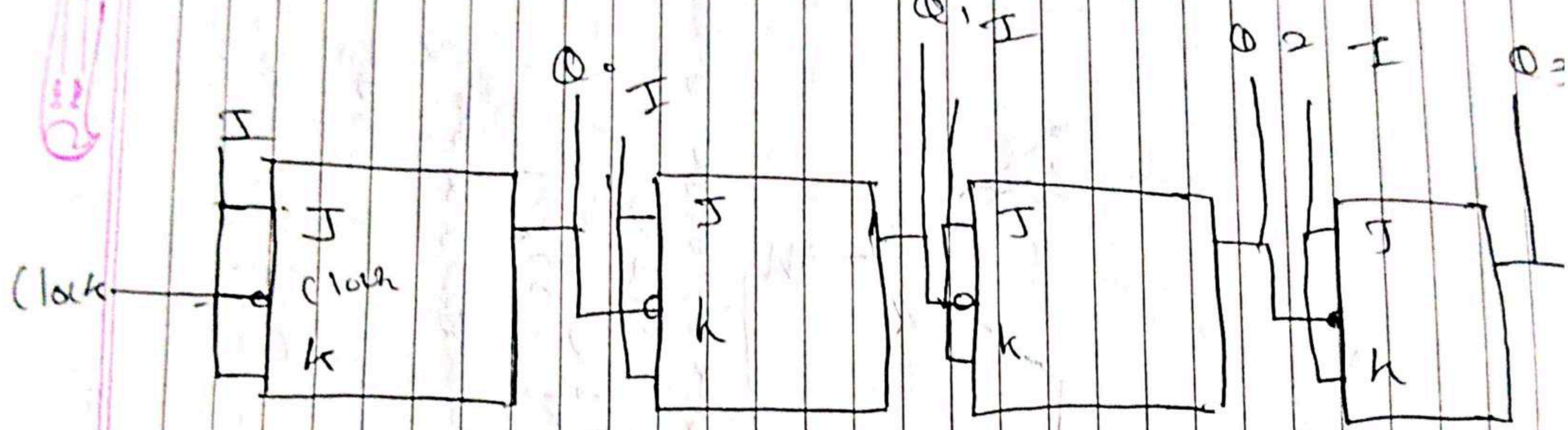
In this way this counter will count 10 pulses from (0000 to 1001)

Ripple Counter:

Ripple Counter is a counter in which output is incremented like a ripple it means it increase from minimum value 0000 to 1111 and again return back to 0000. in this way four - flip flop counter progress from 0 to 15 state all the flip flop are in toogle state and output of One flip flop works as Clock for next flip flop.

As soon as clock occurs at 1st flip flop the output state will change from 0 to 1 in this way every time active low clock pulse active at input the counter output progress ~~from~~ towards from 0000

to 1111 and this is the last state after that flip flop return back to initial state 0000. The ripple counter output normally increase in 2^n States.



Clock	Q_3	Q_2	Q_1	Q_0
	0	0	0	0
	0	0	0	1
	0	0	1	0
	0	0	1	1
	0	1	0	0
	0	1	0	1

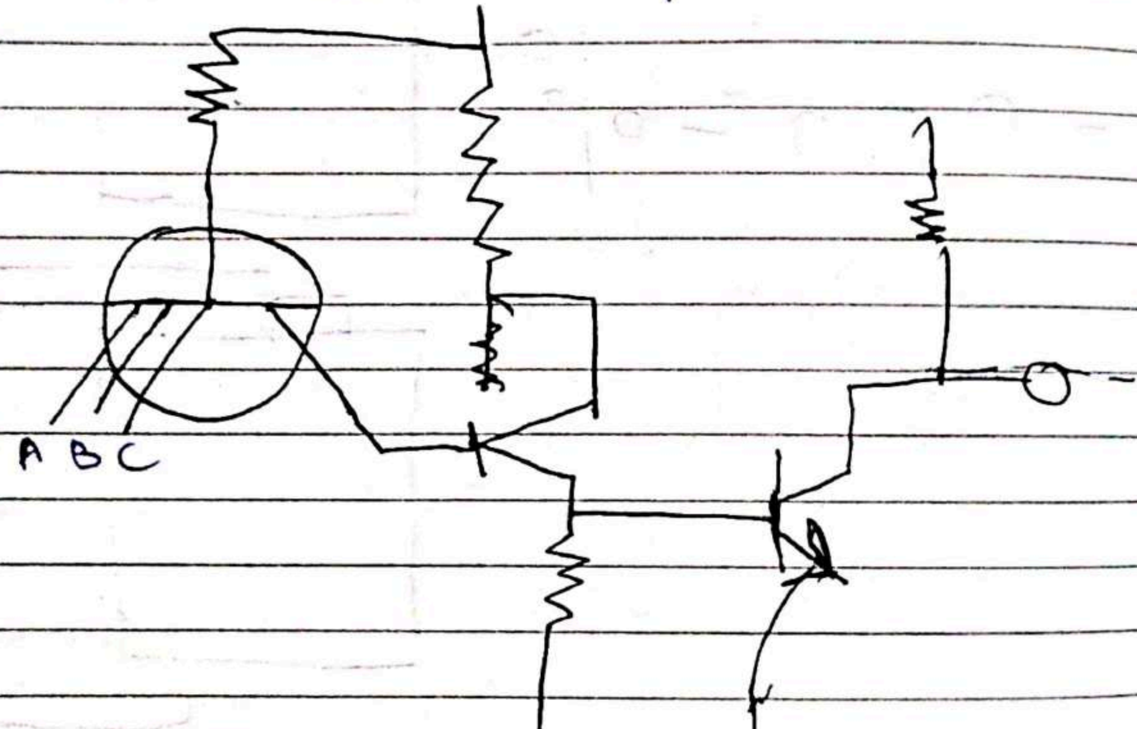
Introduction to Digital IC
TTL

Parameters ~~Digital~~ logic gates fabrication

Speed

Power consumption

TTL logic is advanced version of DTL. It is faster than DTL. DLT has diodes same numbers as input.



Unit - 4

Electric and Magnetic circuit

EMF (Electromotive Force)

Electromotive force is defined as the electric potential produced by either an electrochemical cell or by changing the magnetic field.

$$E = \frac{W}{Q}$$

unit - Volts

Current

Electric current is defined as the rate of flow of electric charge through a conductor.

$$I = \frac{Q}{t}$$

unit - Ampere

Potential Difference

The amount of work done to move a unit positive charge q_0 from one point to another point inside electric field is known as potential diff.

Date :
P. No. :

$$V = \frac{W}{Q}$$

unit - Volts

Power

Power is defined as the work done per unit time

$$P = VI$$

unit - Watt

Energy

Electric Energy is said to be one joule when one ampere of current flows through a circuit for one second when the potential difference is one volt across it

$$E = QV$$

unit - Joules

MMF (Magnemotive Force)

It is a magnetic pressure that tries to set up magnetic flux in a magnetic circuit.

$$MMF = NI$$

Unit = Ampere-turns

Magnetic force / Magnetizing Force / Magnetic field Intensity

Magnetic force or Magnetic Intensity is a vector quantity that measures the strength of a magnetic field at a given point. It is represented by H.

$$H = \frac{B}{\mu_0}$$

unit - Ampere/meter

Permeability

Permeability is the ability of a material to allow the magnetic flux when the object is placed inside the magnetic field.

Magnetic Flux

The number of magnetic field lines passing through unit area.

$$\phi = BA\cos\theta$$

unit = Weber (wb)

Relunctance

It represents the opposition that a material or magnetic circuit presents to the creation of magnetic flux.

$$R = \frac{MMF}{\phi}$$

unit = ~~H^1~~ $Henry^{-1}$

Leakage factor

The leakage factor is defined as the ratio of the total magnetic flux to the useful magnetic flux

$$\lambda = \frac{\phi_{total}}{\phi_{useful}}$$

Electromagnetic Induction

Electromagnetic Induction is the process where a changing magnetic field creates an electric current in a conductor. When a magnet moves near a coil of wire or the coil moves near a magnet electricity is generated in the wire.

Faraday's law of Electromagnetic Induction

First law: When the magnetic field around a conductor changes. It induces EMF in the conductor. This happens if the conductor is part of a closed circuit.

Date :
P. No. :

Second law : The amount of induced EMF is directly proportional to the rate of change of the magnetic field through the conductor.

$$\mathcal{E} = \frac{-N\Delta\phi}{\Delta t}$$

$\mathcal{E}$ = induced voltage
N = number of turns in coil
$\Delta\phi$ = change in magnetic flux
Δt = change in time

Lenz law

Lenz's law states that the direction of the electric current induced in a conductor by a changing magnetic field created by the induced current opposes changes in the initial magnetic field.

$$\mathcal{E} = -N \frac{\Delta\phi}{\Delta t}$$

	Dynamically Induced EMF	Statically Induced EMF
Definition	EMF induced due to the relative motion between magnetic field and conductor	EMF induced due to a change in the magnetic flux linking with a stationary conductor
Motion	Requires motion between conductor and magnetic field	No motion required.
~~Direction~~ Direction	Given by Fleming's Right hand rule	Given by Lenz law
Application	Electric Generators	Transformers
Formula	$E = B.l.v$	$E = -\frac{N\Delta\phi}{\Delta t}$

Date :
P. No. :

Self Inductance

Self Inductance is a property of a coil where a change in the current flowing through the coil induces an EMF in the same coil.

$$L = \frac{N\phi}{I}$$

unit ⇒ henry (H)

Mutual Inductance

Mutual Inductance is a property of a pair of coils where a change in current in one coil induces an emf in the other coil.

$$M = \frac{N_2 \phi_{21}}{I_1}$$

unit ⇒ Henry (H)

Date:
P. No:

B-H Curve / Hysteris Loop

https://byjus.com/jee/hysteresis/

	Electric circuit	Magnetic circuit
1.	Path traced by current is known as electric circuit	Path traced by the magnetic flux is called the magnetic circuit.
2.	EMF is driving force in the electric circuit.	MMF is the driving force in magnetic circuit.
3.	There is a current I in the electric circuit.	There is flux ϕ in the magnetic circuit.
4.	Resistance (R) oppose the flow of current.	Reluctance (S) opposes the flow of magnetic flux.
5.	current $I = \frac{EMF}{Resistance}$	Flux $\phi = \frac{MMF}{Reluctance}$

Date :
P. No. :

Unit - V
A.C. Circuits

Cycle: One complete set of positive and negative values of alternating quantity is known as cycle.

(f) Frequency: It is number of cycles that occur in one second. Unit of frequency Hertz (Hz).

(T) Time period: It is time taken to complete one cycle.

$$T = \frac{1}{f}$$

Amplitude: It is the maximum value positive or negative attained by an alternating quantity. it is also called maximum or peak value.

Date:
P. No:

Average value: The average of all values of an alternating quantity over one cycle is called its average value.

The average value of an alternating quantity over a cycle is zero. Therefore it is defined ~~by~~ over a half cycle.

$$i = I_m \sin \omega t$$

RMS value: The RMS value of an alternating current is that value of steady current or direct current which when flowing through a given circuit for a given time produces the same amount of heat as it produced by the alternating current.

$$I_{rms} = \frac{I_m}{\sqrt{2}}$$

Date :
P. No. :

Form Factor :

The ratio of RMS value of current to its average value is called form factor.

$$\text{Form factor} = \frac{\text{RMS value}}{\text{Average value}}$$

Peak Factor :

The ratio of maximum value to RMS value is called peak factor

$$\text{Peak factor} = \frac{\text{Maximum value}}{\text{R.M.S. value}}$$

Angular Velocity :

Angular velocity is defined as the number of radians covered in one second. The unit is rad/second.

$$\omega = \frac{2\pi}{T}$$

Date:
P. No:

Impedance: The total opposition to flow of AC current in a circuit. It is represented by Z and unit is ohm Ω.

Reactance: The opposition to AC in an electrical circuit caused by inductance or capacitance. It is represented by X and unit is ohm Ω.

Phase angle: The number of electrical degrees of lag or lead between the voltage and current waveform in an AC circuit.

Power Factor: is the ratio of working power measured in kilowatts to apparent power measured in kilovolt amperes.

$$PF = \frac{kW}{KVA} = \frac{\text{True power}}{\text{Apparent power}}$$

Date
P. No

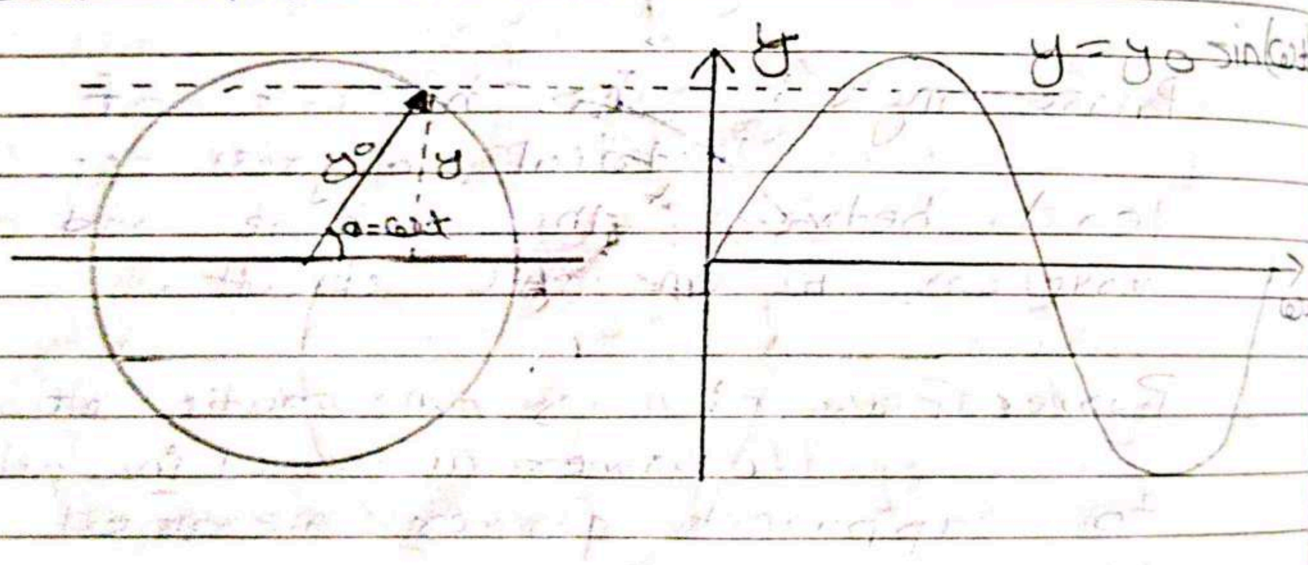
Mathematical representation of
of

EMF ⇒ $E = E_0 \sin(\omega t)$

Current ⇒ $I = I_0 \sin(\omega t)$

Phasor representation of

EMF and Current

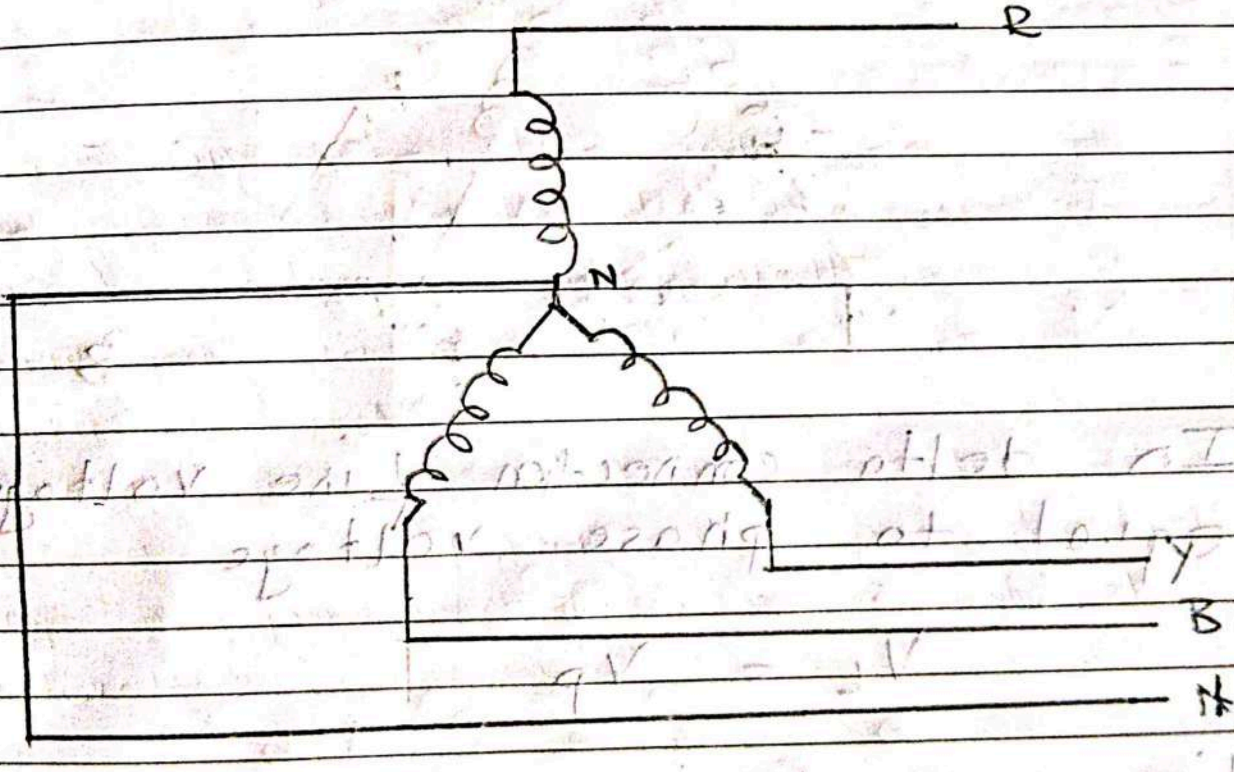


$$\sin(\omega t) = \frac{y}{y_0}$$

$$y = y_0 \sin(\omega t)$$

Voltage and Current Relationship in star and Delta connection.

Star connection



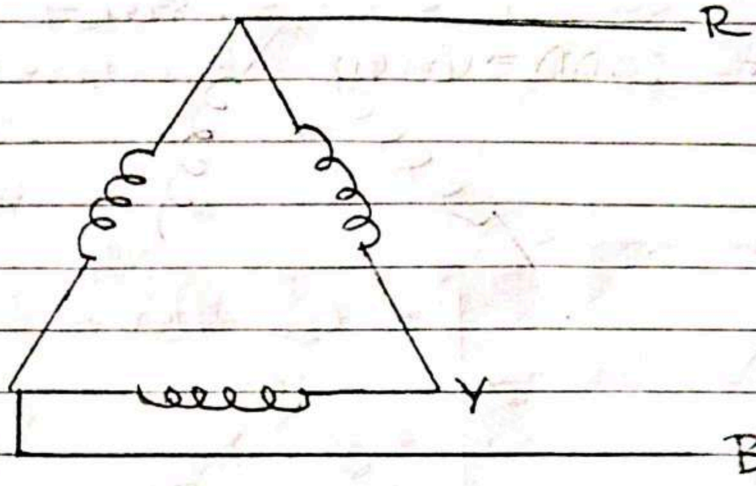
In star connection line current is equal to phase current

$$I_L = I_P$$

In star connection Line voltage is equal to $\sqrt{3}$ times the phase voltage

$$V_L = \sqrt{3} V_P$$

Delta connection



In delta connection Line voltage is equal to phase voltage

$$V_L = V_P$$

Line current is equal to $\sqrt{3}$ times the phase current

$$V_L = \sqrt{3} I_P$$

Different type of Power in AC circuit

True power(P): (Active Power)

True power also known as active power is the power actually consumed or used in AC circuit.

$$P = VI \cos \phi$$

Apparent Power(S):

Apparent power is the total power in AC circuit both used and unused

$$S = VI$$

Reactive power(Q):

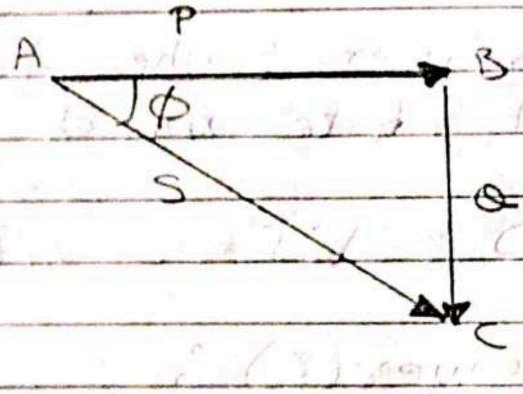
Reactive power is the power that oscillates between the source and the reactive components in an AC circuit.

$$Q = VI \sin \phi$$

Power triangle

Power triangle is ~~the~~ a right angled triangle whose sides represent the active, reactive and apparent power.

Base, perpendicular and hypotenuse of this triangle denotes the active, reactive and apparent power.



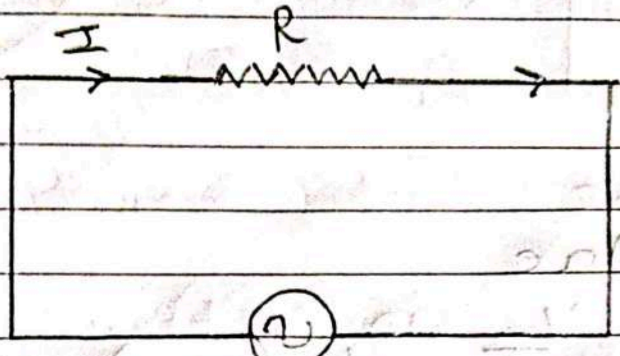
$$\cancel{P^2 = S^2 + Q^2}$$

$$\therefore \quad S^2 = P^2 + Q^2$$

Relation between Active power, reactive power & apparent power

AC in Resistor

A purely resistive circuit has a very negligible amount of inductance such that the reactance offered by such circuits is very small when compared to resistance



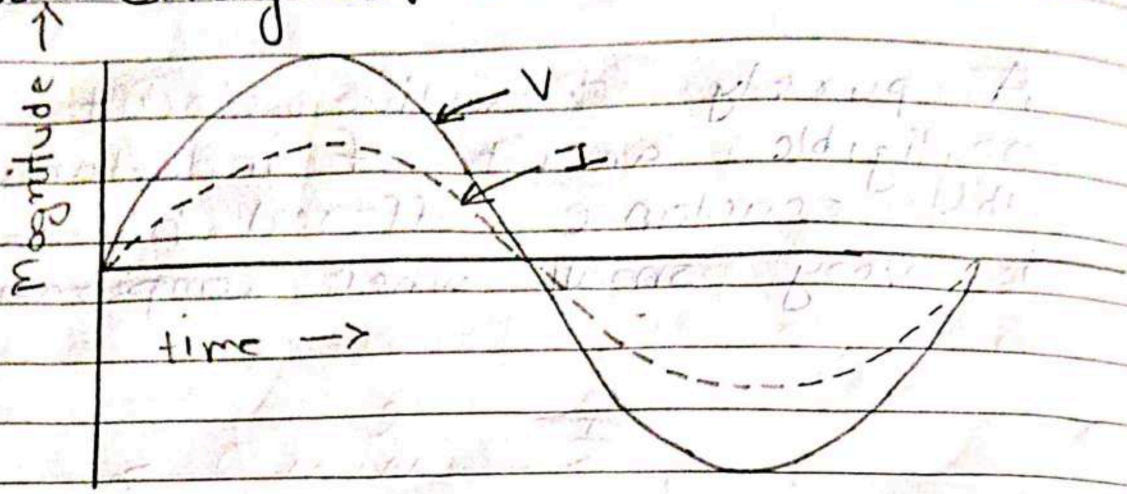
Properties

1. No presence of Inductance and capacitance.

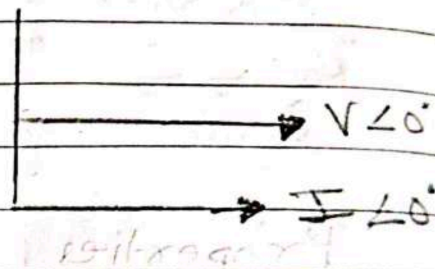
2. The value of current and voltage reaches maximum at same time.

3. The resistor in such a circuit converts electrical energy into heat.

Phasor diagram



Formulae

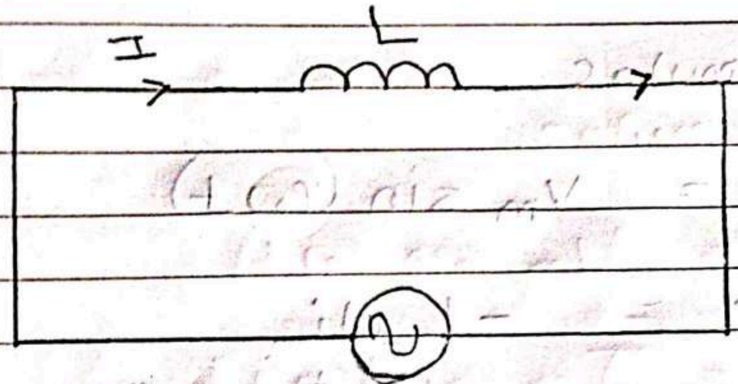


$$I = I_m \sin(\omega t)$$

$$V = V_m \sin(\omega t)$$

AC in Inductor

Such a circuit has zero resistance and hence zero loss. A back EMF due to the self-inductance of coil is produced. Due to absence of resistance the ~~app~~ only force that the applied voltage has to overcome is the circuits self inductance.



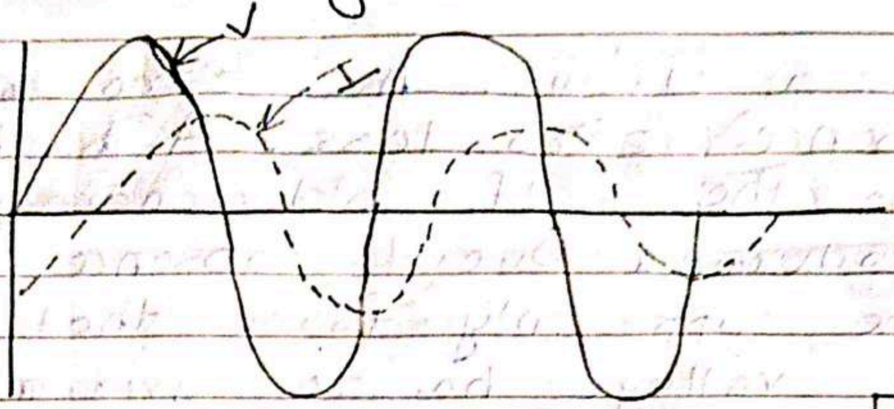
Properties

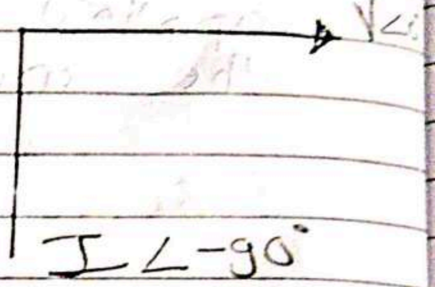
1. The current and voltage values are out of phase with each other by $90°$

2. The current lags the voltage by $90°$

3. No real power is consumed.

Phasor diagram





Formulae

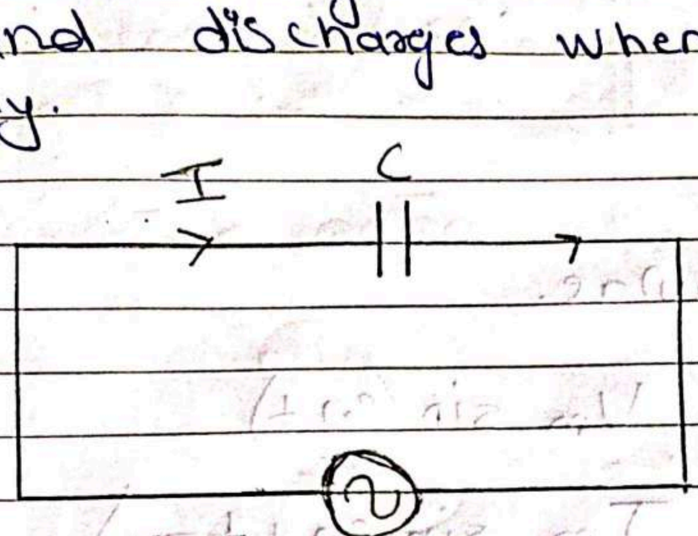
$$V = V_m \sin(\omega t)$$

$$e = -L\frac{di}{dt}$$

$$I = I_m \sin\left(\omega t - \frac{\pi}{2}\right)$$

AC in Capacitor

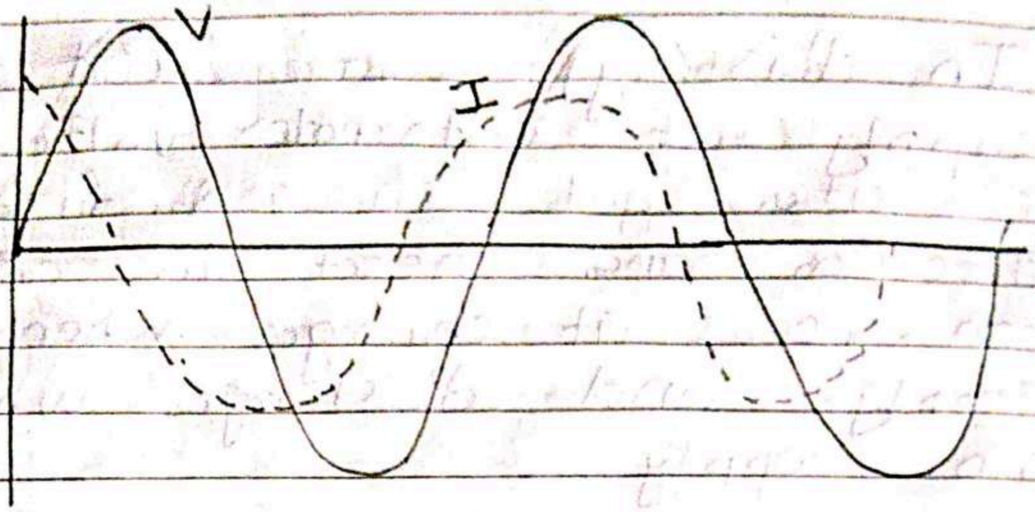
In this type of circuit upon supply of alternate voltage the capacitor gets charged first in one direction and next in another direction. Hence it charges when there is supply and discharges when there is no supply.

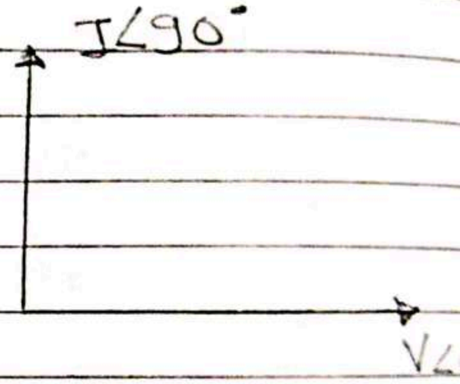


Properties

1. Current leads voltage by 90°
2. During maximum voltage current flow is zero.
3. The current and voltage values are out of phase with each other by 90°

Phasor diagram





Formulae.

$$V = V_m \sin(\omega t)$$

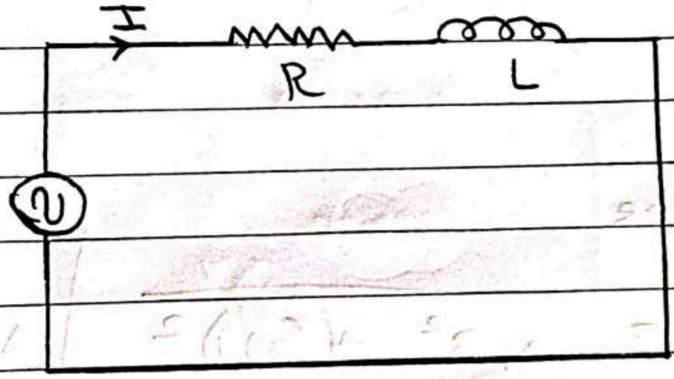
$$I = I_m \sin\left(\omega t + \frac{\pi}{2}\right)$$

$$q = CV$$

Date:
P. No.

R-L circuit (Resistance - Inductance)

A resistor - inductor circuit or RL filter or RL network is an electric circuit composed of resistors and inductors driven by voltage or current source. A first order R-L circuit is composed of one resistor and one inductor either in series or parallel.



R-L Series circuit.

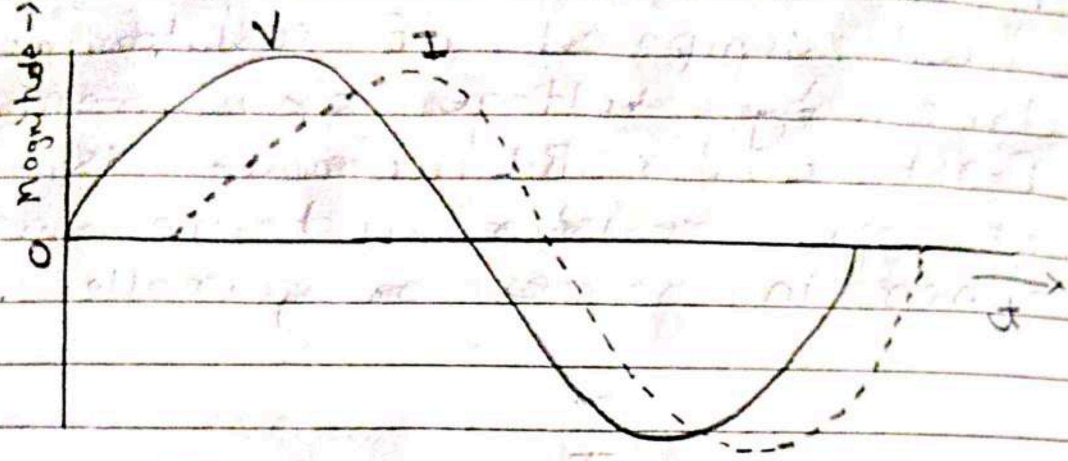
Properties

1. The current Lags behind the voltage by a phase angle ϕ.

2. The impedence is combination of the resistor's resistance R and inductor inductive reactance.

5. The circuit consume real power.

Phase diagram



Formulae

$$Z = \sqrt{R^2 + (\omega L)^2}$$

$$V = V_m \sin(\omega t + \phi)$$

$$I = \frac{V}{Z}$$

$$\phi = \tan^{-1}\left(\frac{\omega L}{R}\right)$$

$$T = \frac{L}{R}$$

Applications of RL circuit

1. Filtering : RL circuits can be used as low-pass or high pass filters in signal processing.

2. Timing circuits: They are used in tuning circuits of radio and TV receivers

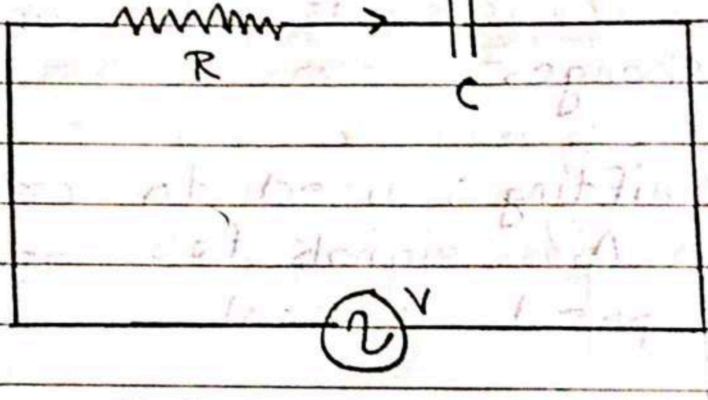
3. Power supplies : Used in power supply circuits to smooth out voltage change.

4. Phase shifting : used to create phase shift in AC signals for applications like motor speed control.

Date :
P. No. :

R - C circuit (Resistance - Capacitance)

An RC circuit is an electrical circuit consisting of a resistor and a capacitor connected in series or parallel with a voltage source. The resistor opposes the flow of current while capacitor stores and releases current energy.



RC circuit

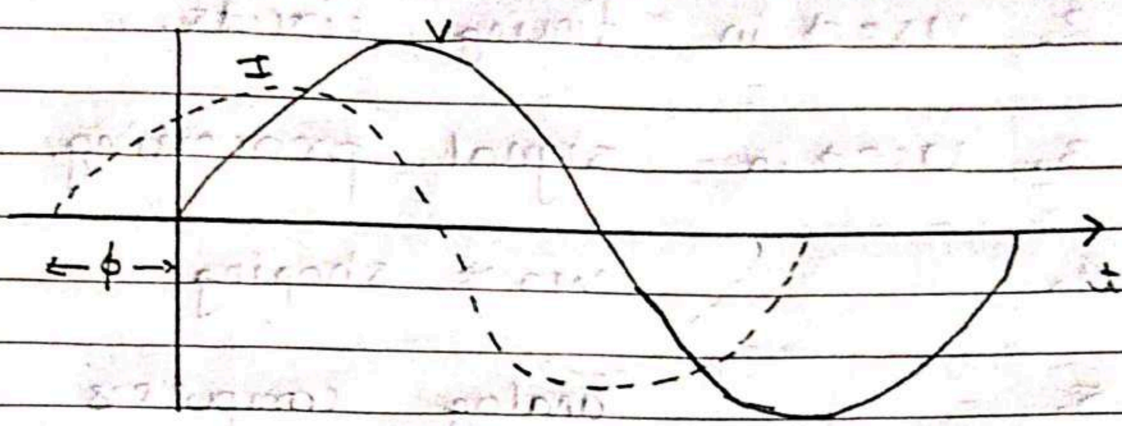
Properties of RC circuit

1. In series RC circuit current lags voltage and in parallel RC circuit voltage lags current.

2. The impedence Z combines resistance and capacitive reactance.

Date:
P. No:

3. time constant $\tau = RC$, it indicates the rate at which the capacitor charges or ~~dischar~~ discharges.



Formulae

$$Z = R + \frac{1}{j\omega C}$$

$$\phi = \tan^{-1}\left(\frac{-1}{\omega RC}\right)$$

$$I = \frac{V_m}{\sqrt{R^2 + \left(\frac{1}{\omega C}\right)^2}} \sin(\omega t + \phi)$$

Applications

1. Used in filter circuit
2. Used in timing circuits
3. Used in signal processing.
4. wave shaping
5. analog computers
6. audio circuits
7. sensor circuits