CLASS NOTES OF

"FUNDAMENTALS OF ELECTRICAL AND ELECTRONIC ENGG"

Technical Classes

✅ Technical Classes के Course में उपलब्ध फीचर्स

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नोट :-

1. सभी ऑफलाइन कक्षाएं Technical Classes के कैंपस तथा सभी ऑनलाइन कक्षाएं Technical Classes के एप्लीकेशन पर चलेगी।
2. यह नोट्स टेक्निकल क्लासेस के स्टूडेंट्स के लिए है, तथा क्लास करने के बाद अधिक प्रभावी होगा।

By Er. Anirudh Sir

I) **Course Curriculum Detailing**: This course curriculum detailing depicts learning outcomes at course level and session level and their attainment by the students through Classroom Instruction (CI), Laboratory Instruction (LI), Term Work (TW) and Self Learning (SL). Students are expected to demonstrate the attainment of Theory Session Outcomes (TSOs) and Lab Session Outcomes (LSOs) leading to attainment of Course Outcomes (COs) upon the completion of the course. While curriculum detailing, NEP 2020 related reforms like Green skills, Sustainability, Multidisciplinary aspects, Society connect, Indian Knowledge System (IKS) and others must be integrated appropriately.

J) Theory Session Outcomes (TSOs) and Units:T2420103

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO.1a Apply the concept of charge, voltage and current in the given electrical circuit TSO.1b Differentiate between AC and DC currents. TSO.1c Differentiate between practical and Ideal current/voltage source TSO.1d Calculate work, power, and energy in the given circuit TSO.1e Calculate the equivalent resistance/Capacitance/ inductance in the given series and parallel electric circuit. TSO.1f Explain the heating/magnetic/chemical effect of the electric current with a relevant application. TSO.1g Calculate the energy stored in a given resistor/capacitor/inductor. TSO.1h Explain the effect of various media on capacitance TSO.1i Explain behavior of current in a resistor/capacitor/inductor.	**Unit-1.0 Basic Electrical Parameters and Concepts** 1.1 Electric charge, flow of charges, Electric Current D.C and A.C, Concept of ideal and practical current sources 1.2 Analogy of charge, potential /Voltage difference D.C and A.C, Induced emf/voltage, Terminal voltage, Concept of Ideal & Practical voltage sources 1.3 Resistor - Properties, Classification, Practical application of resistors, Effect of temperature on resistance, Series and parallel combination of resistors, Phase difference 1.4 Heating, magnetic and chemical effect of current, Electrical work, Power and energy, Open and short circuit condition of electric circuit 1.5 Capacitors – Properties, Capacitance formation, Expression for capacitance, Capacitive reactance, Energy stored in capacitor, Series & parallel combination of capacitors, Types of capacitors including super capacitors and their applications 1.6 Inductors – Properties, Self and mutual inductance, inductive reactance, Voltage and current equations of inductor, Energy stored in inductor, Inductance in A.C. and D.C. circuits, Types of Inductors including MEMS inductor and their applications	**CO-1**
TSO.2a Differentiate between- ● AC and DC current in all aspects (Generation, Waveforms and applications) ● Active and passive elements ● Linear & Non-linear circuit ● Unilateral and Bilateral circuit ● Loop and mesh in a given circuit TSO.2b Apply Ohm's law and Kirchhoff's laws to determine current and voltage in a given circuit. TSO.2c Explain various AC fundamental parameters. TSO.2d Use operator 'j' to calculate various quantities in A.C circuit	**Unit-2.0 Fundamentals of D.C. and A.C. Circuits** **DC Circuits** 2.1 AC and DC current, voltage and Power 2.2 Ohm's law, Kirchhoff's Current Law, Kirchhoff's Voltage law 2.3 Active & Passive elements, Linear & Non-linear circuit, unilateral and Bilateral circuit element, 2.4 Node, Branch, Loop, Mesh **A.C Circuits** 2.5 Frequency, Time period, Amplitude, Angular Velocity, RMS Value, Average Value, Form factor, Peak factor, Power factor 2.6 Phasor representation and transformation from Polar to rectangular form and vice versa of alternating quantities	**CO1, CO2**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO.3a Explain various terms related to magnetic circuit. TSO.3b Calculate various parameters of a given magnetic circuit. TSO.3c Plot B-H curve and Hysteresis loop of a given magnetic materials TSO.3d Explain the phenomenon of induced e.m.f and current TSO.3e Apply principles of Faraday's law to calculate induced e.m.f in the given circuit TSO.3f Apply various Laws in a given magnetic circuits	**Unit-3.0 Magnetic Circuits and Electromagnetic Induction** 3.1 Magnetic flux, Magnetomotive force, Magnetic field strength, Permeability, Reluctance. 3.2 Magnetic leakage, leakage coefficient 3.3 Magnetic Hysteresis, Hysteresis loop, 3.4 Magnetization (B-H) Curve 3.5 Analogy between electric and magnetic circuits 3.6 Electromagnetism 3.7 Induced e.m.f -Statically (self and mutual) and dynamically induced emf, 3.8 Faraday's Laws of electromagnetic Induction. 3.9 Lenz's Law, Fleming's R.H. rule; direction of induced E.M.F, Fleming's L.H. rule, Ampere's Law	**CO2, CO3**
TSO.4.a Describe the construction and working principle of the given type of semiconductor TSO.4.b Describe the principle of the given type of semiconductor. TSO.4.c Describe between the given type insulator, conductor and semiconductor based on energy band theory. TSO.4.d Describe working principle, characteristics and application of the given type of diode. TSO.4.e Describe working principle of the given type of Bipolar Junction Transistor. TSO.4.f Describe working principle of the given type of Field Effect Transistor.	**Unit-4.0 Basic Electronic Components** 4.1 Semiconductors: Definition, types of semiconductors and their materials. Energy band theory and effect of temperature. 4.2 Diodes: Basic Concept of Diodes, N-type & p-type PN Junction Diode – Forward and Reverse Bias Characteristics i.e., PN junction Barrier voltage, depletion region, Junction Capacitance. Forward biased & reversed biased junction, Diode symbol 4.3 Bipolar Junction Transistor (BJT): NPN and PNP Transistor – Operation and characteristics. symbol 4.4 Field Effect Transistor (FET): FET – Operation and characteristics, Classification FET and advantages, FET symbol	**CO4**
TSO.5a Convert one number system to other number system. TSO.5b Use Boolean Algebra to solve expressions TSO.5c Implement Boolean expressions for given logic gates	**Unit-5.0 Overview of Digital Electronics** 5.1 Introduction to different Number systems: Binary, Octal, Decimal & Hexadecimal & their Conversion from one another 5.2 Introduction to Boolean Algebra, rules and Laws of Boolean Algebra – DE Morgan's Law 5.3 Study of logic gates (NOT, OR, NOR, AND, NAND) Symbolic representation, Truth Table and Implementation of Boolean expressions	**CO4, CO5**

Note: One major TSO may require more than one Theory session/Period.

Charge

Charge is the inherent [Physical] Property of material which experience force on itself or another body.
It is denoted by 'Q' or 'q'
It's Unit is Coloumb [C]

There are two types of Charge:–

Charges

+ve charge

−ve charge

+ve charge is carried by Proton

Proton has $+ \underbrace{1.6\times10^{-19}}C$

−ve charge is carried by electron.

Electron has $- \underbrace{1.6\times10^{-19}}C$

→ In Any atom, No. of Protons is equal to No. of electrons
So Atom is electrically neutral.

E.g:– Na → 11

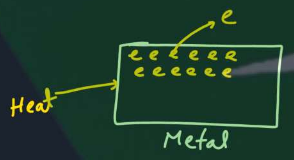
No. of Protons in Na = 11 $\xrightarrow{\text{Charges}}$ $+1.6\times10^{-19}\times11$

+ No. of electrons in Na = 11 $\xrightarrow{\text{Charges}}$ $-1.6\times10^{-19}\times11$

Total Charges $= (+1.6\times10^{-19}\times11) - 1.6\times10^{-19}\times11 = 0$

* Electron Jumps from Lower energy band to higher Energy band, when electron absorbs energy.

Electron Jumps from higher energy level to lower energy level then electron releses energy.



In a Sodium atom one electron releses then remaing No. of electrons = 10.

$Na \rightarrow 11, \rightarrow \underbrace{2, 8,}\ \boxed{1} \rightarrow$ Remove from Na-Atom

10 electrons $\xrightarrow{\text{Charges}} -1.6\times10^{-19}C \times 10$

While No. of Proton = 11 $\xrightarrow{\text{Charge}} +1.6\times10^{-19}C\times11$

$\boxed{Na^{+}}$

Total charges = $(+1.6\times10^{-19}C\times11) + (-1.6\times10^{-19}C\times10)$

$+1.6\times10^{-19}C\,(11-10) = +1.6\times10^{-19}C \times 1$

Revision

$Mg \rightarrow 12 \rightarrow 2,\ 8,\ \boxed{2} \rightarrow$ Remove

No. of Protons = 12 $\xrightarrow{\text{Charge}} +1.6\times10^{-19}C\times12$

No. of electrons = 12 − 2 = 10 $\xrightarrow{\text{Charge}} -1.6\times10^{-19}C\times10$

Total Charges = $(+1.6\times10^{-19}C\times12) + (-1.6\times10^{-19}C\times10)$

$= +1.6\times10^{-19}C\,(12-10)$

$= +\underbrace{1.6\times10^{-19}C}\times 2$ $\qquad Mg^{++}$

$Cl \rightarrow 17 \rightarrow 2, 8, \underline{7+1}$ $\boxed{Cl^-}$ e

No. of Proton = 17 $\xrightarrow{\text{charges}}$ $+1.6\times10^{-19}C \times 17$

No. of electron = 17 $\xrightarrow{\text{charges}}$ $-1.6\times10^{-19} \times 17$

Total charge = $+1.6\times10^{-19}C \times 17 - 1.6\times10^{-19} \times 17$

$= +1.6\times10^{-19}C\,(17-17)$

$= +1.6\times10^{-19}C \times 0 = 0$

One electron adds in Cl-atom.

total No. of e = 18

∵ No. of Proton = 17 $\xrightarrow{\text{charge}}$ $+1.6\times10^{-19}C \times 17$

No. of electron = 18 $\xrightarrow{\text{charge}}$ $-1.6\times10^{-19}C \times 18$

Total charge = $+1.6\times10^{-19}C \times 17 - 1.6\times10^{-19}C \times 18$

$= +1.6\times10^{-19}C\,(17-18)$

$= +1.6\times10^{-19}C \times -1$

$= -1.6\times10^{-19}C$

Charge is created on atom by Gaining or loosing electron

Loss of electron → +Ve Charge

Gain of electron → −Ve Charge

Charge

+Ve Charge

+Ve Charge is Carried by Proton

$P = +1.6\times10^{-19}C$

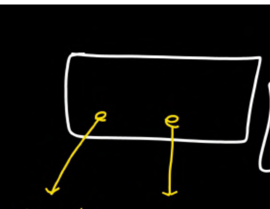
−Ve Charge

−Ve Charge is carried by electrons.

$e = -1.6\times10^{-19}C$

☆ When electron removes from matter then +Ve Charge is created.

☆ When electron enters in atom then −Ve Charge is created.



$+1.6\times10^{-19}C$

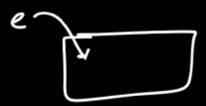
$$\boxed{q = 1.6\times10^{-19}C}$$

If 1 electron removes $= +1.6\times10^{-19}C \times 1 = 1\times e$

2 electrons removes $= +1.6\times10^{-19} \times 2 = 2e$

3 electrons removes $= +1.6\times10^{-19} \times 3 = 3e$

$+ne$



If 1 electron enters $= -1\times1.6\times10^{-19}c$

If 2 electrons enter $= -2\times1.6\times10^{-19}c$

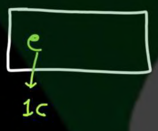
⋮

$= -ne$

→ Quantisation of Charge:–

Charge on any material is integral multiple of 'e'

i.e $\boxed{q = \pm ne}$



$Na \rightarrow 11 \rightarrow \underbrace{2,8,}①$

$\downarrow$

Na^+

$\because \; 1e = -\underline{1.6\times10^{-19}}c$

$$\boxed{1\,C = 625\times10^{16}\text{ electrons}}$$

$1.6\times10^{-19}c = 1e$

$1c = \frac{1}{1.6\times10^{-19}}e$

$1c = \frac{10}{}\times10^{19}e$

$1. \quad \frac{\overset{25}{\cancel{500}}}{\cancel{1000}}\times10^{16}$ $= 625\times10^{16}$ electr

$\cancel{16}$

4

4)2500(625

24

10

8

20

20

$1.6\times10^{-19}c = 1e$

$1c = \frac{1}{1.6\times\underline{10}^{-19}}e$

$1c = \frac{10}{16}\times\underline{10}^{19}e$

$10^3\times10^{16}$

$1c = \frac{10\times10^3}{16}\times10^{16}$

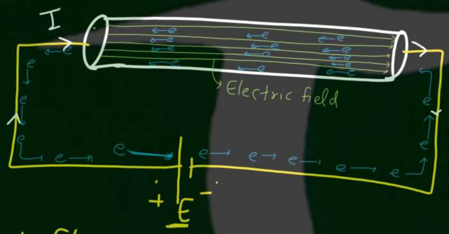
* Charge:-

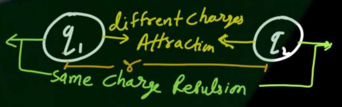
* Current:-

→ Charges flow Per unit time is called Electric current.

$$\boxed{I = \frac{q}{t}} \rightarrow \frac{1C}{1\,sec} = \frac{625 \times 10^{16}\,\text{electrons}}{Sec}$$

→ Current is the flow of free electrons.





$F \propto q_1 q_2$ — ①

$F \propto \frac{1}{r^2}$ — ②

$F \propto \frac{q_1 q_2}{r^2}$

$$\boxed{F = \frac{1}{4\pi\epsilon} \times \frac{q_1 q_2}{r^2}}$$

- * Current flows in any metal due to applied electric field.
- * Current flows in the direction of electric field.
- * –ve Charges flow against the electric field. While +ve Charges flow in the direction of electric field.
- ☆ Current flows in the opposite direction of electrons movement.

* Current density (J)

→ Current flows per unit cross sectional area is called Current density. It is denoted by J.

i.e. $\boxed{J = \frac{I}{A}}$ $I \rightarrow$ Amp. $A \rightarrow m^2$

ie.

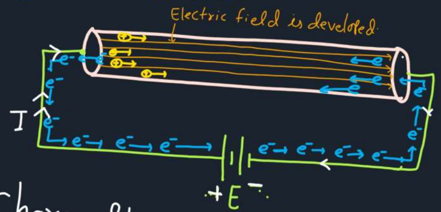
$A\,m^2 = I$

Unit of current density is Amp/m^2

$$\boxed{1\,m^2 = \frac{I}{A}} = J$$

flow of Charges ⇒

→ When Electric field applied on any metal then Charges Start to flow.



+ve Charges flow in the direction of Electric field.

−ve Charges flow in opposite direction of Electric field.

electron has −ve Charges

Concept of Current

* Current → Charges flow Per Unit time is called electric Current. It is denoted by 'I'

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

Wher I is Current. It's Unit is Ampere.

Q is Charge. It's Unit is Coloumb.

t is time. It's Unit is Second.

∵ As We Know that

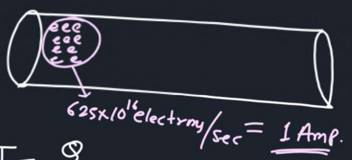
$$1e^- \longrightarrow \underbrace{-1.6 \times 10^{-19}C}$$

$$1.6 \times 10^{-19}C \longrightarrow 1 \text{ electron}$$

$$1\,C \longrightarrow \frac{1}{1.6} \times 10^{+19} \text{ electrons}$$

$$1\,C \longrightarrow \frac{10}{1.6} \times 10^{18} \text{ electrons}$$

$$1C \longrightarrow \frac{\overset{\overset{625}{\cancel{2500}}}{\cancel{10000}}}{\underset{4}{\cancel{16}}} \times 10^{16} = 625 \times 10^{16} \text{ electron}$$



625×10^{16} electrons/sec = 1 Amp.

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

Charges flow per unit time

i.e. If 1C charge flows in one second, then it is known as One Ampere current

≈ 625×10^{16} electrons flow in one second, then current is One Ampere.

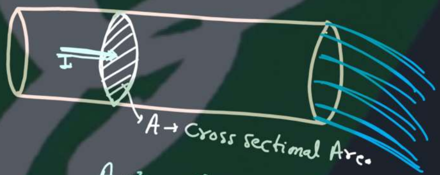
2 Amp current = $2 \times 625 \times 10^{16}$ electrons/sec

5 Amp current = $5 \times 625 \times 10^{16}$ electrons/second

* Current density :-

Current flows per unit area is known as Current density.

It is denoted by 'J'



$J = \frac{I}{A}$

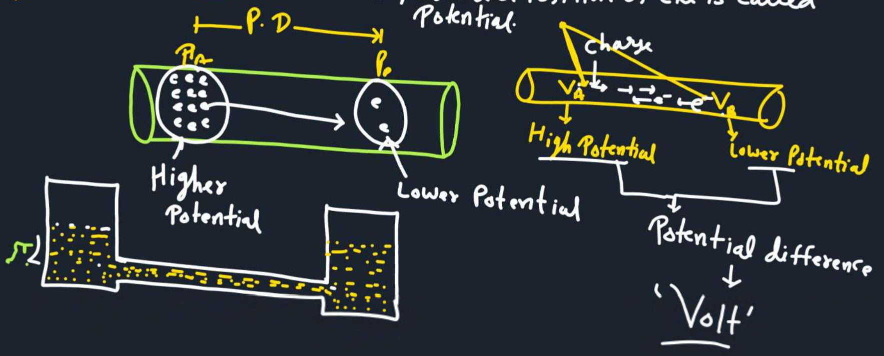
A m^2 = I current

1 m^2 = $\frac{I}{A}$ = current density (J)

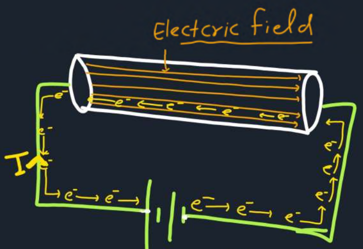
Unit of current density is Ampere/m^2.

Concept

Potential → Work done to bring unit charge from infinite position to particular position of ckt is called Potential.



Potential diffencen & E.M.F



+ E − → 5V → 4.9V → 4.8V → 4.7V

EMF → Electro Motive force

Maximum P.D between both Electrod of Cell/ Battery Under no Current is Called E.M.F

Potential at Point A is V_A
Higher Potential

Potential at Point B
V_B (lower Potential)

Potential → Work done to Bring Unit Charge from infinite Potion is Called Potential.

Voltage :–

Voltage is the Pressure from an Electrical Circuit Power Sources that Pushes Charges (Electrons) in Electrical Circuit or loop.

or

$$\boxed{V=\frac{W}{q}}$$

in Short we can Say that

$$\boxed{\text{Voltage} = \text{Pressure}}$$

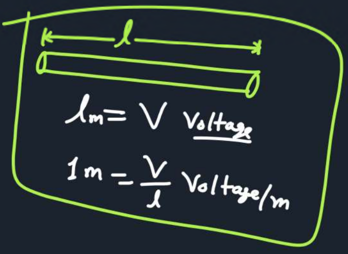
S.I Unit of Voltage is Volt. It is equal Joule/Coloumb

* Electric field Intensity (E)

→ Voltage developed per unit length in a ckt is called Electric field Intensity. It is denoted by E.

i.e. $\boxed{E = \frac{V}{l}}$

It's Unit is Volt/m



Current

Current density

Voltage

Electric field Intensity

Current density	Electric field Intensity
$\boxed{J = \frac{I}{A}}$	$\boxed{E = \frac{V}{l}}$

Ohm's Law :→

$R = \rho \frac{l}{A}$ ($\rho \rightarrow$ Resitivity or Specific Resistanc)

Ohm's Law states that:-

At Constant temperature & Pressure Current density in a Circuit/conductor is directly Proportional to the Electric field Intensity.

ie $J \propto E$ or $\boxed{J = \sigma E}$

Here $\overset{\text{Sigma}}{\sigma}$ is Conductivity or Specific conductance

$\boxed{\sigma = \frac{1}{\rho}}$

Sigma

$\rho \rightarrow$ Rho

$J \propto E$

$\frac{I}{A} \propto \frac{V}{l}$

Cell constant → $\frac{l}{A} \propto \frac{V}{I}$

$\boxed{I \propto V}$

V↑, I↑

V↓, I↓

$\Rightarrow \boxed{J = \sigma E}$

$\frac{I}{A} = \sigma \frac{V}{l}$

$\frac{l}{A} = \sigma \frac{V}{I}$

$\frac{1}{\sigma} \frac{l}{A} = \frac{V}{I}$

$\boxed{\rho \frac{l}{A}} = \frac{V}{I}$

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

$\boxed{V = IR}$

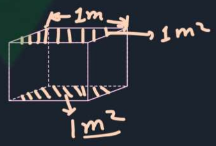
$\frac{V}{R} = I$

$I = \boxed{\frac{1}{R}} \times V$ $\left[\frac{1}{R} = G \right]$

$G \rightarrow$ Conductance

$\boxed{I = G \times V}$

$\boxed{J \propto E}$



$J = \sigma E$

$\sigma \rightarrow$ Sigma - Specific Conductanc → Conductivity

$\boxed{\sigma = \frac{1}{\rho}}$ $\rho \rightarrow$ Rho → Resistivity

$J = \sigma E$

$\frac{I}{A} = \sigma \frac{V}{l}$

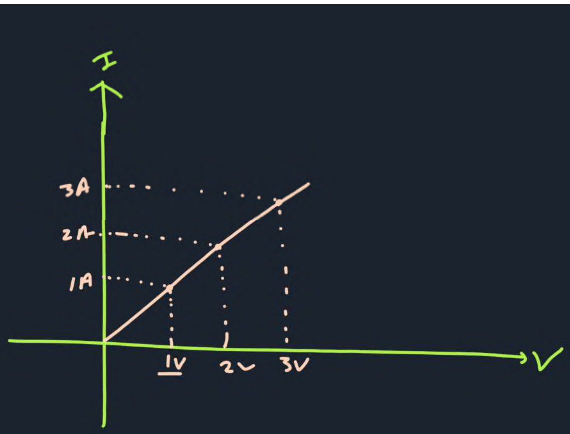
$\frac{l}{A} = \sigma \frac{V}{I}$

$\frac{1}{\sigma} \cdot \frac{l}{A} = \frac{V}{I}$

$\rho \frac{l}{A} = \frac{V}{I}$

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

$\boxed{V = RI}$



Ohm's Law

$J \alpha E$

$\boxed{J = \sigma E}$

$\boxed{V = IR}$

$\boxed{I = VG}$

$\boxed{J = \frac{dQ}{dt}}$

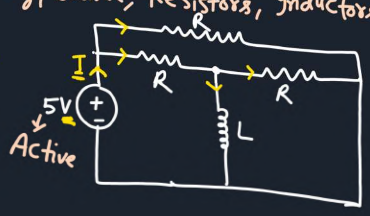
$\boxed{V = R \cdot \frac{dQ}{dt}}$

Electrical Circuit

Any Close loop in Which current flows is called Electric Circuit.

Electric circuit Consists active and Passive Elements like Energy Source, Resistors, Inductors, Capacitor etc.

E.g:-



* Voltage

* Current

Active Element :-

Element which gives (Genenerates) Energy to the Circuit is Called active element.

E.g:- Energy Sources, Transistor

↳ It Increases the Strength of Signal.

Passive Elements

Element which Stores energy or Utilizes Energy is Known as Passive Element.

E.g:- Resistor, Inductor, Capacitor

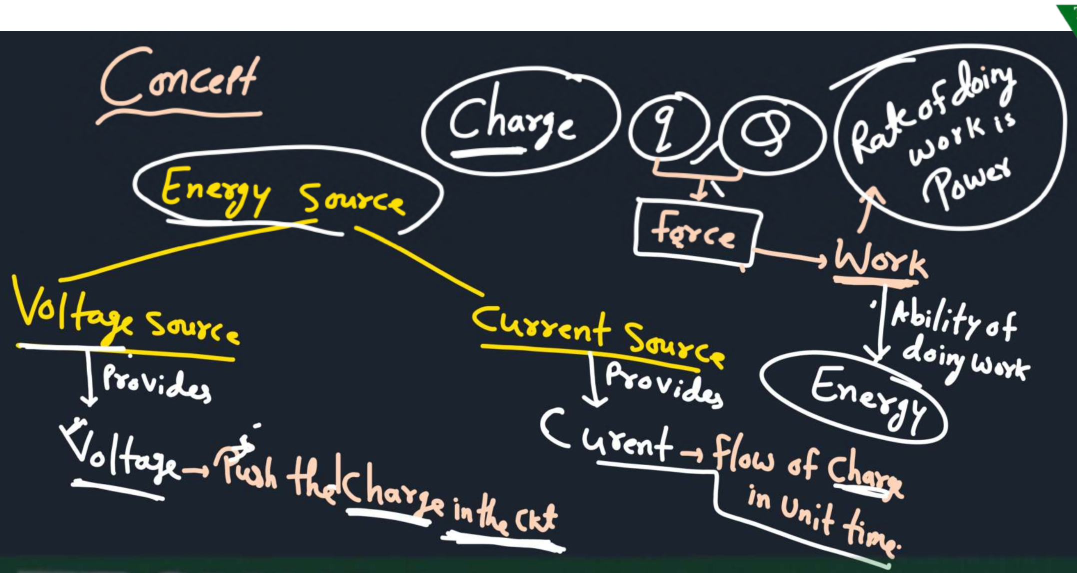
Energy Sources

The device Which is Capable to Provide Energy in Circuit is Known as Energy Source.

There are two form of energy Source in Electrical Ckt:-

1) Voltage Source 2) Current Source.

Concept



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It is denoted by 'Q' or 'q'

It's Unit is Coloumb [C]

There are two types of charge:—

Charges

+ve charge is carried by Proton

Proton has $+ 1.6 \times 10^{-19} C$

−ve charge is carried by electron.

Electron has $- 1.6 \times 10^{-19} C$

→ In Any atom, No. of Protons is equal to No. of electrons So Atom is electrically neutral.

E.g:- Na → $\underline{11}$

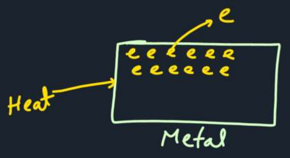
No. of Protons in Na = 11 $\xrightarrow{\text{Charges}}$ $+1.6 \times 10^{-19} \times 11$

+ No. of electrons in Na = $\underline{11}$ $\xrightarrow{\text{Charges}}$ $-1.6 \times 10^{-19} \times 11$

Total Charges = $(+\underline{1.6 \times 10^{-19}} \times 11) - \underline{1.6 \times 10^{-19} \times 11} = \underline{0}$

* Electron Jumps from Lower energy band to higher Energy band, when electron absorbs energy.

Electron Jumps from higher energy level to lower energy level then electron releses energy.



In a Sodium atom one electron releses then remaing No. of electrons = 10.

Na → 11, → $\underbrace{2, 8,}$ $\boxed{1}$ → Remove from Na-Atom

'10 electrons $\xrightarrow{\text{Charges}}$ $-1.6 \times 10^{-19} C \times \underline{10}$

$\boxed{Na^{+}}$

While No. of Proton = 11 $\xrightarrow{\text{Charge}}$ $+1.6 \times 10^{-19} C \times 11$

Total Charges = $(+\underline{1.6 \times 10^{-19}} C \times \underline{11}) + (-1.6 \times 10^{-19} C \times 10)$

$+ 1.6 \times 10^{-19} C\,(\underline{11 - 10}) = \underline{+1.6 \times 10^{-19}} C \times \underline{1}$

Revision

$Mg \rightarrow 12 \rightarrow 2,\ 8,\ \boxed{2} \rightarrow$ Remove

No. of Protons = 12 $\xrightarrow{\text{Charge}} +1.6\times10^{-19}C\times12$

No. of electrons = 12 − 2 = 10 $\xrightarrow{\text{Charge}} -1.6\times10^{-19}C\times10$

$$\text{Total Charges} = (+1.6\times10^{-19}C\times12)+(-1.6\times10^{-19}C\times10)$$

$$= +1.6\times10^{-19}C\ (12-10)$$

$$= +\underbrace{1.6\times10^{-19}C}\times2$$

Mg^{++}

$Cl \rightarrow 17 \rightarrow 2,\ 8,\ \underline{7+1}$

$\boxed{Cl^-}$ ← e

No. of Proton = 17 $\xrightarrow{\text{Charges}} +1.6\times10^{-19}C\times17$

No. of electron = 17 $\xrightarrow{\text{Charges}} -1.6\times10^{-19}\times17$

$$\text{Total Charge} = +1.6\times10^{-19}C\times17 - 1.6\times10^{-19}\times17$$

$$= +1.6\times10^{-19}C\ (17-17)$$

$$= +1.6\times10^{-19}C\times0 = 0$$

One electron adds in Cl-atom.

total No. of e = 18

∵ No. of Proton = 17 $\xrightarrow{\text{Charge}} +1.6\times10^{-19}C\times17$

No. of electron = 18 $\xrightarrow{\text{Charge}} -1.6\times10^{-19}C\times18$

$$\text{Total charges} = +1.6\times10^{-19}C\times17 - 1.6\times10^{-19}C\times18$$

$$= +1.6\times10^{-19}C\ (17-18)$$

$$= +1.6\times10^{-19}C\times-1$$

$$= -1.6\times10^{-19}C$$

Charge is Created on atom by Gaining or loosing electron

Loss of electron → +Ve Charge

Gain of electron → −Ve Charge

Charge

+ve Charge

+ve Charge is Carried by Proton

$P = +1.6 \times 10^{-19} C$

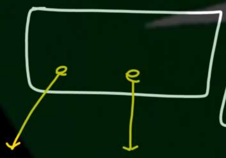
-ve Charge

-ve Charge is carried by electrons.

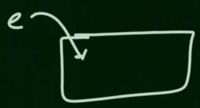
$e = -1.6 \times 10^{-19} C$

☆ When electron removes from matter then +ve charge is created.

☆ When electron enters in atom then -ve charge is created.



$$\boxed{q = 1.6 \times 10^{-19} C}$$



$+1.6 \times 10^{-19} C$

If 1 electron removes $= +1.6 \times 10^{-19} C \times 1 = 1 \times e$

2 electrons removes $= +1.6 \times 10^{-19} \times 2 = 2e$

3 electrons removes $= +1.6 \times 10^{-19} \times 3 = 3e$

$+ne$

If 1 electron enters $= -1 \times 1.6 \times 10^{-19} C$

If 2 electrons enter $= -2 \times 1.6 \times 10^{-19} C$

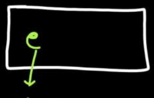
⋮

$= -ne$

→ Quantisation of Charge:-

Charge on any material is integral multiple of 'e'

i.e $\boxed{q = \pm ne}$



1c

$Na \rightarrow 11 \rightarrow \underbrace{2, 8}_{Na^+}, ①$

$\because \quad 1e = -\underbrace{1.6\times10^{-19}}c$

$$\boxed{1C = 625\times10^{16}\text{ electrons}}$$

$1.6\times10^{-19}c = 1e$

$1c = \frac{1}{1.6\times10^{-19}}e$

$1c = \frac{10}{16}\times10^{19}e$

$1. \quad \frac{\cancel{500}\ \cancel{5000}}{\cancel{16}\ 4}\times10^{16} = 625\times10^{16}\text{ electro}$

$4)\,2500(625$
24
10
8
20
20

$1.6\times10^{-19}c = 1e$

$1c = \frac{1}{1.6\times10^{-19}}e$

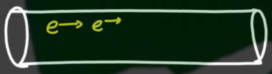
$1c = \frac{10}{16}\times10^{19}e$

$10^{3}\times10^{16}$

$1c = \frac{10\times10^{3}}{16}\times10^{16}$

* Charge:-

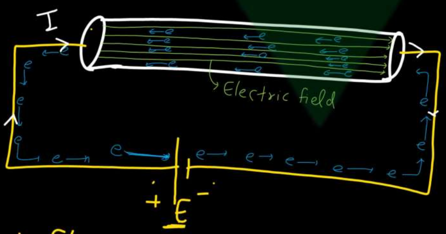
* Current:-

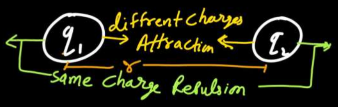


→ Charges flow per unit time is called Electric current.

$$\boxed{I = \frac{q}{t}} \rightarrow \frac{1C}{1\,sec} = \frac{625\times10^{16}\text{ electrons}}{sec}$$

→ Current is the flow of free electrons.





$F \propto q_1 q_2$ — ①

$F \propto \frac{1}{r^2}$ → ②

$F \propto \frac{q_1 q_2}{r^2}$

$$\boxed{F = \frac{1}{4\pi\epsilon}\times\frac{q_1 q_2}{r^2}}$$

* Current flows in any metal due to applied electric field.

* Current flows in the direction of electric field.

* -ve Charges flow against the electric field. While +ve Charges flow in the direction of electric field.

☆ Current flows in the opposite direction of electrons movement.

* Current density (J)

→ Current flows per unit cross sectional area is called Current density. It is denoted by J.

i.e. $\boxed{J = \frac{I}{A}}$ → Amp. → m²

ie.

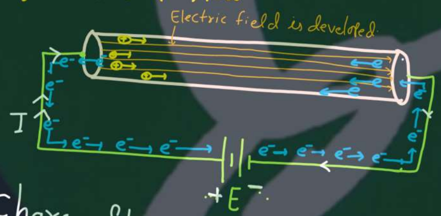
$A\,m^2 = I$

$\boxed{1\,m^2 = \frac{I}{A}} = J$

Unit of current density is Amp/m²

Flow of Charges ⇒

→ When Electric field applied on any metal then Charges start to flow.



+ve Charges flow in the direction of Electric field.

−ve Charges flow in opposite direction of Electric field.

electron has −ve Charges

Concept of Current

* Current → Charges flow per unit time is called electric Current. It is denoted by 'I'

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

Wher I is Current. It's Unit is Ampere.

Q is Charge. It's Unit is Coloumb.

t is time. It's Unit is Second.

∵ As we know that

$$1e^- \longrightarrow \underbrace{-1.6\times10^{-19}C}$$

$$1.6\times10^{-19}C \longrightarrow 1\ \text{electron}$$

$$1C \longrightarrow \frac{1}{1.6}\times10^{+19}\ \text{electrons}$$

$$1C \longrightarrow \frac{10}{1.6}\times10^{19}\ \text{electrons}$$

$$\underline{1C} \longrightarrow \frac{\overset{625}{\cancel{\overset{2500}{\cancel{10000}}}}}{\underset{4}{\cancel{16}}}\times10^{16} = \underline{625\times10^{16}\ \text{electrons}}$$

625×10^{16} electrons/sec = $\underline{1\text{ Amp.}}$

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

2 Amp current = $2\times625\times10^{16}$ electrons/sec

5 Amp current = $5\times625\times10^{16}$ $\underline{\text{electrons/second}}$

Charges flow per unit time

i.e. If $\underline{1C}$ charge flows in one second, then it is known as One Ampere current

≈ $\underline{625\times10^{16}}$ electrons flow in one second, then Current is One $\underline{\text{Ampere.}}$

* $\underline{\text{Current density}}$:-

Current flows per unit area is known as Current density.

It is denoted by 'J'

$A\ m^2 = I$ current

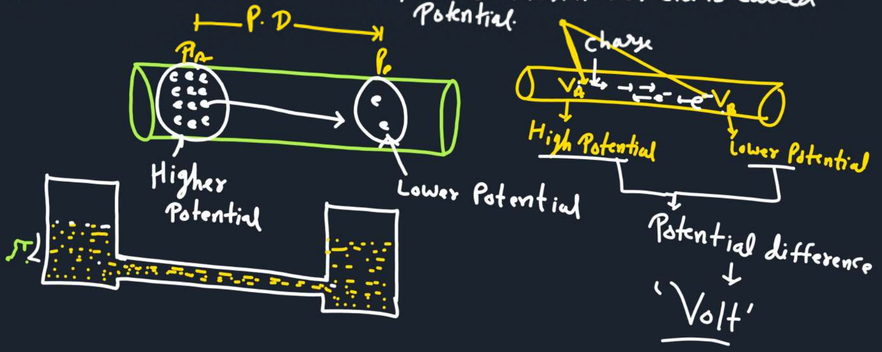
$1m^2 = \frac{I}{A} =$ current density (J)

₹ $J = \frac{I}{A}$

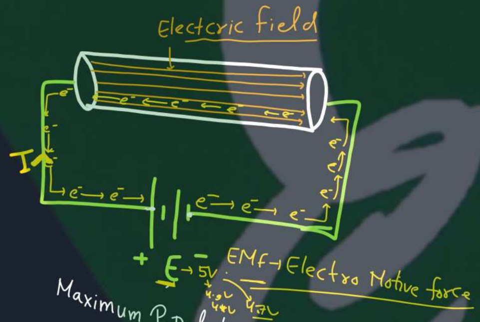
Unit of Current density is $\underline{\text{Ampere}/m^2}$.

Concept

Potential → Work done to bring Unit Charge from infinite Position to Particular Position of ckt is called Potential.



Potential diffencen & E.M.F



EMF → Electro Motive force

Maximum P.D between both Electrod of cell/ Battery under no current is called E.M.F

Potential at Point A is V_A
Higher Potential

Potential at Point B
V_B (lower Potential)

Potential → Work done to bring Unit Charge from infinite Potion is called Potential.

Voltage :-

Voltage is the Pressure from an Electrical Circuit Power Sources that Pushes Charges (Electrons) in Electrical Circuit or loop.

or

$$\boxed{V = \frac{W}{q}}$$

in Short we can say that

$$\boxed{\text{Voltage} = \text{Pressure}}$$

S.I Unit of Voltage is Volt. It is equal Joule/Colamb

* Electric field Intensity (E)

→ Voltage developed per unit length in a ckt is called Electric field Intensity.

It is denoted by E.

i.e. $\boxed{E = \frac{V}{l}}$

It's Unit is Volt/m

lm = V Voltage

$1m = \frac{V}{l}$ Voltage/m

Current

Current density

Voltage

Electric field Intensity

Current density

$$\boxed{J = \frac{I}{A}}$$

Electric field Intensity

$$\boxed{E = \frac{V}{l}}$$

Ohm's Law :→

$R = \rho \frac{l}{A}$ (ρ → Resitivity or Specific Resistance)

Ohm's Law states that:-

At Constant temperature & Pressure Current density in a Circuit/conductor is directly Proportional to the Electric field Intensity.

ie $J \propto E$ or $\boxed{J = \sigma E}$

Here $\underset{\text{Sigma}}{\sigma}$ is Conductivity or Specific conductance

$$\boxed{\sigma = \frac{1}{\rho}}$$

Sigma → σ, ρ → rho

$J \propto E$

$\frac{I}{A} \propto \frac{V}{l}$

cell constant → $\frac{l}{A} \propto \frac{V}{I}$

$$\boxed{I \propto V}$$

V↑, I↑
V↓, I↓

$\Rightarrow \boxed{J = \sigma E}$ ✓

$\frac{I}{A} = \sigma \frac{V}{l}$

$\frac{l}{A} = \sigma \frac{V}{I}$

$\frac{1}{\sigma} \frac{l}{A} = \frac{V}{I}$

$\boxed{\rho \frac{l}{A}} = \frac{V}{I}$

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

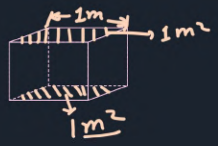
$\boxed{V = IR}$ ✓

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

$I = \boxed{\frac{1}{R}} \times V$ $\left[\frac{1}{R} = G \right]$ G ↓ Conductance

$\boxed{I = G \times V}$ ✓

$\boxed{J \propto E}$



$J = \sigma E$

Sigma – Specific Conductance → Conductivity

$\boxed{\sigma = \frac{1}{\rho}}$ → Rho → Resistivity

$J = \sigma E$

$\frac{I}{A} = \sigma \frac{V}{l}$

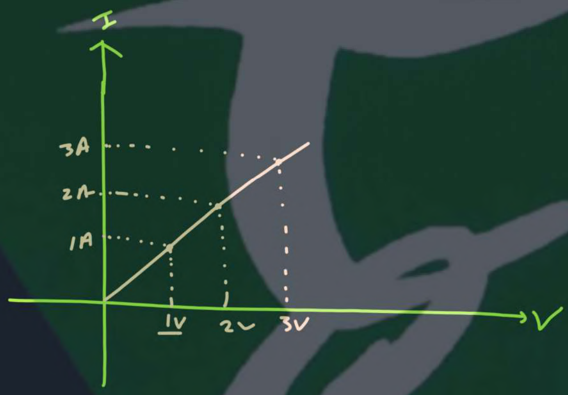
$\frac{l}{A} = \sigma \frac{V}{I}$

$\frac{1}{\sigma} \cdot \frac{l}{A} = \frac{V}{I}$

$\rho \frac{l}{A} = \frac{V}{I}$

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

$\boxed{V = RI}$



Ohm's Law

$J \propto E$

$\boxed{J = \sigma E}$

$\boxed{V = IR}$

$\boxed{I = VG}$

$\boxed{J = \frac{dQ}{dt}}$

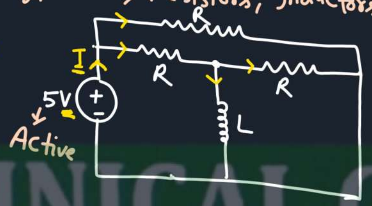
$\boxed{V = R \cdot \frac{dQ}{dt}}$

Electrical Circuit

Any Close loop in which current flows is called Electric Circuit.

Electric circuit Consists active and Passive Elements like Energy Source, Resistors, Inductors, Capacitor etc.

E.g:-



* Voltage

* Current

Active Element :-

Element which gives (Genenerates) Energy to the Circuit is Called active Element.

E.g:- Energy Sources, Transistor

↳ It Increases the Strength of Signal.

Passive Elements

Element which Stores energy or Utilizes Energy is Known as Passive Element.

E.g:- Resistor, Inductor, Capacitor

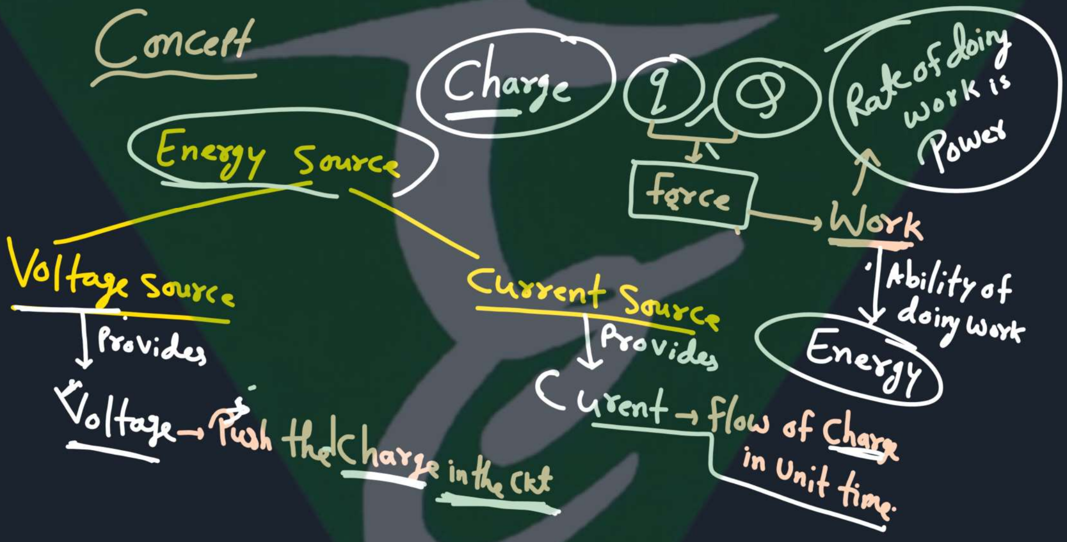
Energy Sources

The device Which is Capable to Provide Energy in Circuit is Known as Energy Source.

There are two form of energy Source in Electrical Ckt:-

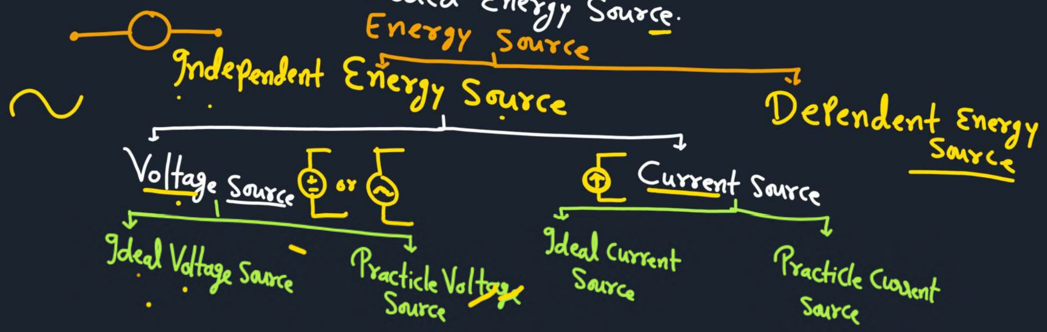
1) Voltage Source 2) Current Source.

Concept



Energy Source

The device which is Capable to give Energy to the Circuit is Called Energy Source.

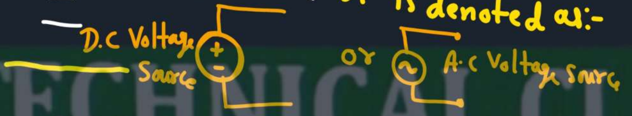


Voltage Source

The device Which is Capable to give Voltage to the Circuit is Called Voltage Source.

→ Generally we are discussing about Independent Voltage Source.

→ A device Which Produces Voltage Independently is Independent Voltage Source. It is denoted as:-



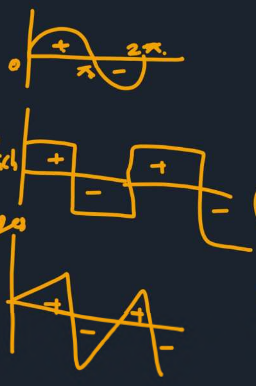
A.C

Electrical Quantity Which Polarity [Direction] Changes after fixed interval is Known as A.C Quantity.

E.g:-

Electrical Q

A.C → Electrical Quantity which Polarity changes after fixed interval.



D.C → Electrical Quantity Which Polarity doesnot change.

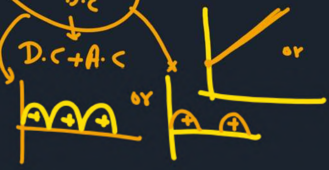
D.C

Pulsating D.C

D.C+A.C

Varrying D.C

Fixed D.C



Independent Voltage Sources are further Classified into two Categories

1) Ideal Voltage Source :- No loss

2) Practicle Voltage Source
↳ few loss

* Ideal Voltage Source :-

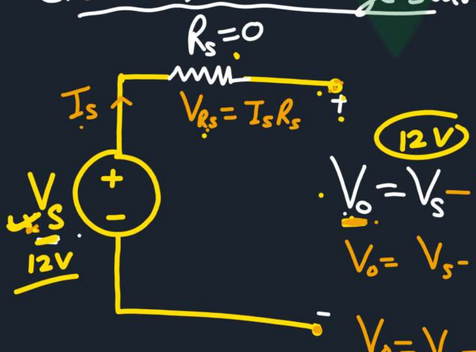
A device which gives all generated Voltage across its terminals is Known as Ideal Voltage Source.

There is no loss in Ideal Voltage Source.

The internal resistance of device (Ideal Voltage Source) is Connected in Series and represented as R_s.

The Value of R_s is Zero in Ideal Voltage Source.

Ckt of Ideal Voltage Source



$V_o = V_s - V_{R_s}$ [$V_{R_s}=I_sR_s$]

$V_o = V_s - I_sR_s$ [$\because R_s=0$]

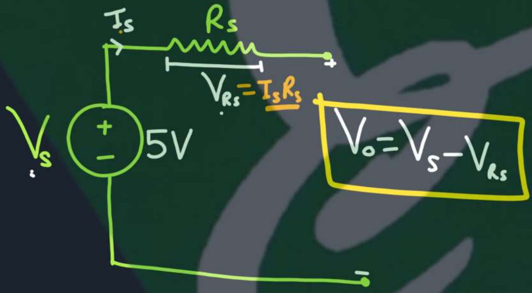
$V_o = V_s - 0$

$\boxed{V_o=V_s}$ ✓

Energy Source

- Independent Energy Source
  - Voltage Source
    - Ideal Voltage Source
    - Practicle Voltage Source
  - Current Source
    - Ideal Current Source
    - Practicle Current Source
- Dependent Energy Source

Voltage Source :→



Ideal Voltage Source

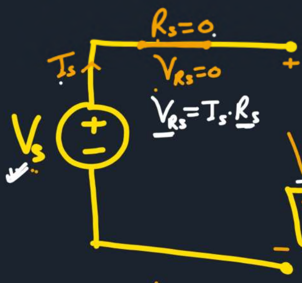
A device which gives all generated Voltage across it's terminals is Called Ideal Voltage Source.

There is No loss in Ideal Voltage Source.

Because it's Internal Resistance is Zero

$R_s = 0$

Ideal Voltage Source is shown below:-



$V_o = V_s - V_{R_s}$

$\boxed{V_o = V_s}$

$\because V_{R_s} = I_s \times R_s \quad (\because R_s = 0)$

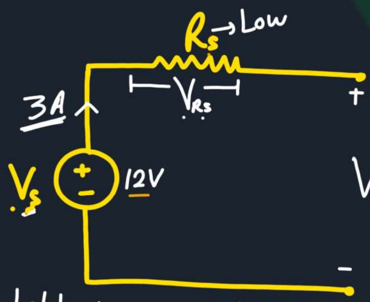
$V_{R_s} = 0$

* Practicle Voltage Source:-

A device which give less Voltage than generated Voltage across it's terminals.

It has few loss due to internal Resistance R_s.

The Value of Internal Resistance R_s Should be as low as Possible.

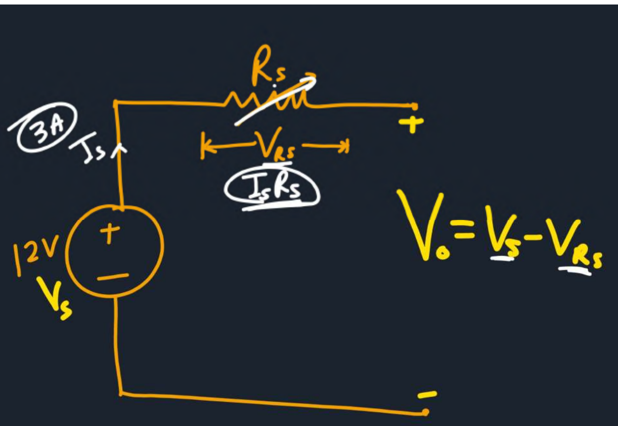


$V_o = V_s - V_{R_s}$

Example → Let be $V_s = 12V$

$I_s = 3A$

$R_s = 3\Omega$	$R_s = 1\,\Omega$	$R_s = 0.5$	$R_s = 0.1$
$V_{R_s} = I_s R_s$	$V_{R_s} = I_s R_s$	$V_{R_s} = I_s R_s$	$V_{R_s} = I_s R_s$
$V_{R_s} = 3 \times 3 = 9V$	$V_{R_s} = 3 \times 1 = 3V$	$V_{R_s} = 3 \times \frac{0.5}{10} = 1.5V$	$V_{R_s} = 3 \times 0.1 = 0.3V$
$V_o = V_s - V_{R_s}$	$V_o = V_s - V_{R_s}$	$V_o = 12V - 1.5V$	$V_o = 12V - 0.3V$
$V_o = 12V - 9V$ $= 3V$	$V_o = 12V - 3V = 9V$	$= 10.5V$	$= 11.7V$

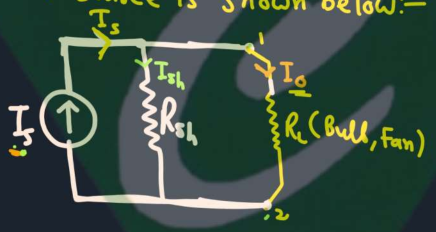


$$V_o = V_s - V_{Rs}$$

Current Source

An Energy Source which Produces current through it's terminals is known as Current Source.

Current Source is shown below:–



There are two types of Current Sources:→

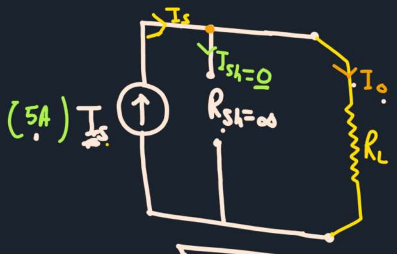
① Ideal Current Source → No loss

② Practicle Current Source → few loss

Ideal Current Source :-

→ A current Source which has no loss, is Ideal c.s.

It's Internal Resistance is infinite ($R_{sh}=\infty$)



$I_s = I_{sh} + I_o$ [$\because R_{sh}=\infty, I_{sh}=0$]

$I_s = 0 + I_o$

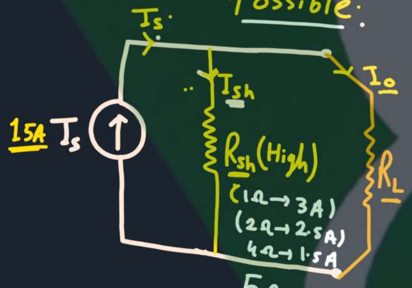
$\boxed{I_s = I_o}$

$\boxed{I_o = I_s}$

Practicle C.S

→ Few loss

→ Internal Resistance R_{sh} Should be as high as Possible.



(1Ω → 3A)
(2Ω → 2.5A)
4Ω → 1.5A
5Ω → 1.A
6Ω → 0.5A
7Ω → 0.25A

Concept

$I_s = I_{sh} + I_o$

$\boxed{I_o = I_s - I_{sh}}$

$I_s = 15A$

R_{sh}	I_{sh}	I_o
1Ω	3A	12A
2Ω	2.5A	12.5A
4Ω	1.5A	13.5A
5Ω	1A	14A
6Ω	0.5A	14.5A
7Ω	0.25	14.75A

Electric ckt

- Voltage
- Current
- Current density
- Electricfield Intensity
- Energy Source

Tarun Sir
↓
Anirudh Sir

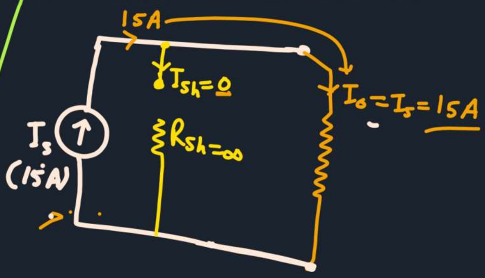
Current Source

$$I_s = I_{sh} + I_o$$

0

$\boxed{R_{sh}=\infty}$

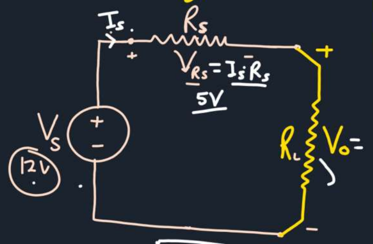
Ideal Current Source.



Energy Source

- Independent E.S
  - Voltage Source
    - Ideal Voltage Source
    - Practicle V.S
  - Current Source
    - Ideal C.S
    - Practicle C.S
- Dependent E.S

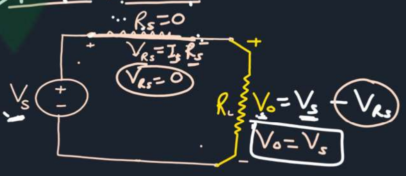
Voltage Source



$\boxed{V_o = V_s - V_{Rs}}$

Ideal Voltage source (No loss)

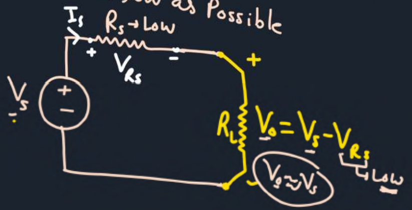
$R_s = 0$, $V_o = V_s$



$\boxed{V_o = V_s}$

Practicle V.S (Few low)

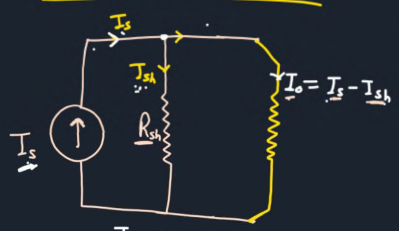
R_s as low as Possible



$V_o = V_s - V_{Rs}$ → Low

$\boxed{V_o \approx V_s}$

Current Source



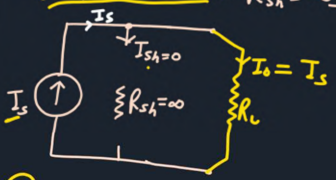
$I_s = I_{sh} + I_o$

$I_s - I_{sh} = I_o$

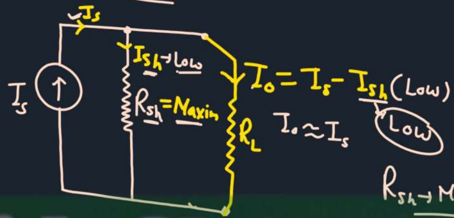
$I_o = I_s - I_{sh}$ ($I_{sh} = 0$)

$\boxed{I_o = I_s}$

Ideal C.S ($\frac{\text{No Loss}}{R_{sh} = \infty}$)



Practicle C.S

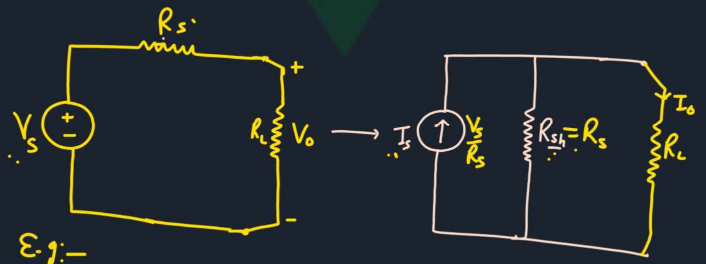


$R_{sh} \to$ Maximum

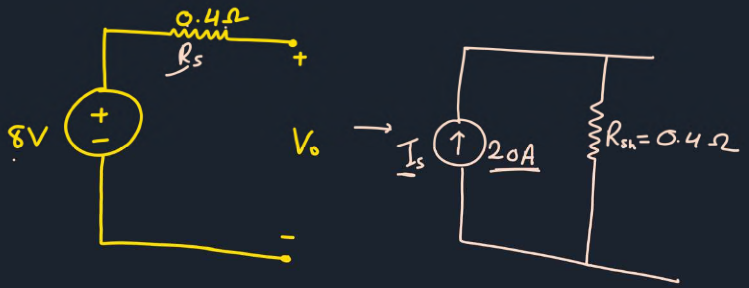
$\boxed{V = IR}$ C.S → V.S

$\boxed{I = \frac{V}{R}}$ V.S → C.S

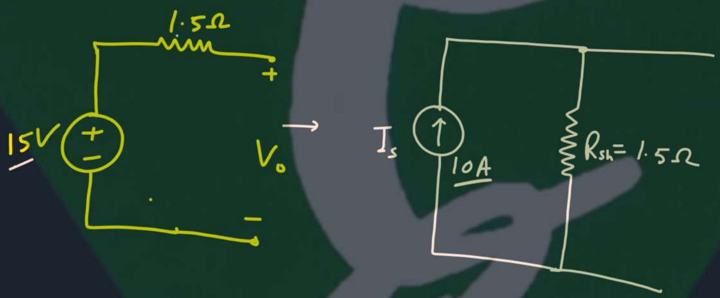
Conversion from V.S to C.S



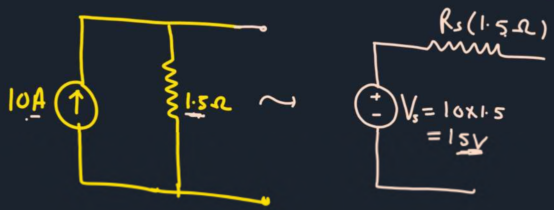
E.g.:-



$I_s = \frac{V_s}{R_s} = \frac{\overset{20}{\cancel{80}}}{0.4}$ $\qquad I_s = \frac{V_s}{R_s} = \frac{\overset{20}{\cancel{80}}}{0.4}$



$I_s = \frac{V_s}{R_s} = \frac{\overset{10}{\cancel{150}}}{\cancel{1.5}}$



Element of Electrical Circuit:-

A) Active Element:-

Element which gives Energy to the Circuit is Called active Element.

Eg:- Energy Source, Vaccum tube, Semiconductor devices

Except Diode

Energy Source

Transistor → BJT, FET

OP-Amp.

B) Passive Element

→ Passive Element doesnot give Energy to the Circuit.

While Passive Elements Converts Energy into following:-

① Heat :- Resistor has ability to Convert Electrical Energy into heat. So Resistor is a Passive Element.

② Electric field :- Capacitor has ability to Store Energy in Electric field as Voltage. So Capacitor is also a Passive Element.

③ Magnetic field :- Inductor has ability to Store Energy in magnetic field as Current. So Inductor is also a Passive Element.

Concept:- **Resistor:**

$\boxed{P = VI}$ $\boxed{V = IR}$

$P = IR \times I = I^2R$

$\boxed{P = I^2R}$

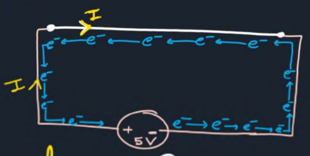
Power → Rate of doing work.

$\boxed{\text{Power} = \frac{\text{Work}}{\text{time}}}$

$\boxed{\text{Work} = \text{Power} \times \text{time}}$

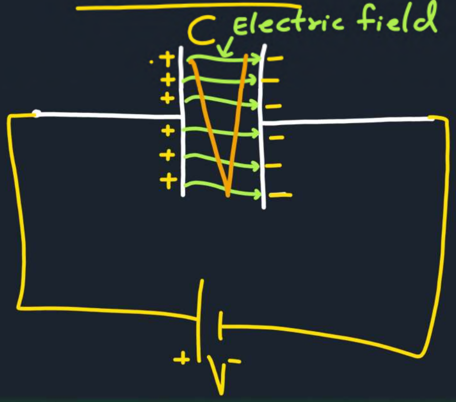
$\text{Heat} = I^2R \times t$

$\boxed{H = I^2Rt}$



Resistor Produces heat So Resistor is a Passive Element.

Capacitor



$Q \propto V$

$Q = C \cdot V$

C is Capacitance

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

Inductor

Resistor

Resistor is a Passive two terminals Electrical Component that implements electrical Resistance as Circuit Element.

In Electronic Circuits, resistors are used to reduce Current flow, adjust Signal level, and divide Voltage.

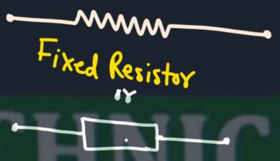
We can design a Voltage divider $\overset{\text{Circuit}}{\text{ckt}}$ by Resistors.

There are two types of Resistors:-

1) Fixed Resistor

→ Resistor which resistance doesnot change is known as fixed Resistor.

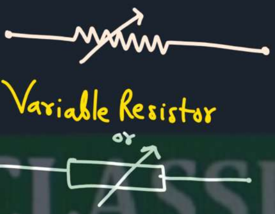
Symbol:-



2) Variable Resistor

→ Resistor which resistance Changes is known as Variable Resistor.

Symbol



Resistance

→ The Property of material due to which it opposes a flow of current through it is called Resistance.

→ It depends upon length, Cross Sectional Area and nature of material.

It is denoted by R.

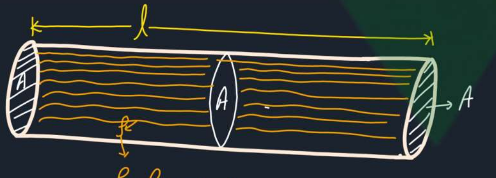
Mathematically:- $\boxed{R = \rho \frac{l}{A}}$

where

ρ → Resistivity (Specific Resistance)

l → length of Conductor

A → Cross Sectional Area



ρ → Resistivity or Specific Resistance
↓
Depends on Material

* Unit of Resistance is Ohm 'Ω'

$R \propto l$ — ①

$R \propto \frac{1}{A}$ — ②

Combining eqⁿ ① & ②, we have:-

$R \propto \frac{l}{A}$ or $\boxed{R = \underset{\downarrow}{\rho} \frac{l}{A}}$

→ Resistance is the ratio of Potential Difference across two end of a Conductor to the Current flowing through them.

$$\boxed{\text{i.e } R = \frac{V}{I}}$$

$$\boxed{\frac{V_{AB}}{I} = \text{Resistance}}$$

$V = IR$

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

Resistivity or Specific Resistance

It is the resistance of the material of Unit length and Unit area of Cross section.

It is denoted by ρ

$$\boxed{\rho = R \cdot \frac{A}{l}}$$

If $A = 1\,m^2$
$l = 1\,m$

Unit of Resistivity (ρ) is ohm-meter Ω-m

Resistivity is indendent of length of material and Area of Cross section

But It depends on Nature of material.

Resistor → Device

↳ which opposes the flow of current

$R = \rho \frac{l}{A}$

$$\boxed{\frac{R \cdot A}{l} = \rho}$$

$R = \rho \frac{l \to 1m}{A \to 1m^2}$

$R_{specific} = \rho \left(\frac{1}{1}\right)$

$R_{specific} = \rho$

Resistance is Property of material which opposes the flow of current. $\left[\underset{\text{ohm}\,(\Omega)}{R} = \rho \frac{l}{A}\right]$

Specific Resistance or Resistivity (ρ) → $l = 1m$, $A = 1m^2$

Ω-m

$R = \rho \times \frac{1}{1}$

$R_{specific} = \rho$

→ Resistance Canbe measured by Measuring Instrument like Ohmmeter, Ratio Meter Megger and Multimeter.

→ Resistance Canbe Calculated by Colour Code.

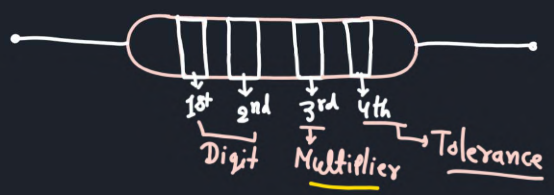
Colour Code

→ Colour Code is a technique which helps us to Calculate Resistance and tolerance of Resistor.

→ Colour code is also known as Resistance Calculator.

→ Resistor has different Colour band which help us to determine Resistance of Resistor.

Generally We are 4 band Resistor.



B B R O Y lived in Great Britain had Very Good Wife

B → Black
B → Brown
R → Red
O → Orange
Y → Yellow
G → Green
B → Blue
V – Violet
G – Gray
W – White

Colour	1st & 2nd Band Digit	3rd Band Multiplier	Tolerance.
Black	0	$\times 10^0 = 1$	
Brown	1	$\times 10^1 = 10$	
Red	2	$\times 10^2 = 100$	
Orange	3	$\times 10^3 = 1000$	
Yellow	4	$\times 10^4$	
Green	5	$\times 10^5$	
Blue	6	$\times 10^6$	
Violet	7	$\times 10^7$	
Gray	8	$\times 10^8$	
White	9	$\times 10^9$	
Gold	—		±5%
Silver	—		±10%

Gold → ±5%
Silver → ±10%
None → ±20%

B – 0
B – 1
R – 2
O – 3
Y – 4

2 3 ±10%

$$\boxed{R = 23 \times 10^4 \Omega \pm 10\%}$$

$$23 \times 10 \times 10^3 \Omega \pm 10\%$$

$$230 \times 10^3 \Omega \pm 10\%$$

$$230\,k\Omega \pm 10\%$$

$$R = 230\,K\Omega \pm 10\%$$

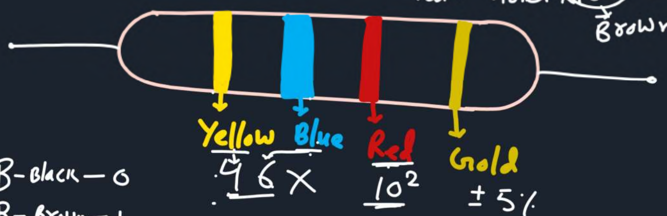
230 kΩ − 23 kΩ to 230 kΩ + 23 kΩ

207 kΩ to 253 kΩ

$470\,\Omega \pm 10\%$ → Silver

Yellow, Violet $\times 10^1$ → Brown

Colour 9



4 6 × 10^2 ± 5%

B - Black — 0
B - Brown — 1
R - Red — 2 $\times 10^2$
O - orange — 3
Y - Yellow — 4
Green — 5
Blue — 6
Violet — 7

$46 \times 10^2\,\Omega \pm 5\%$

$4.6 \times 10^3\,\Omega \pm 5\%$

$4.6\,k\Omega \pm 5\%$

$4.6 \times 10^2 \times \frac{10}{10}$

4.6×10^3

$10^3 \rightarrow k\Omega$
$10^6 — M\Omega$
$10^9 — G\Omega$

Colour Coding

→ Colour coding is a technique which helps us to Calculate resistance and tolerance of Resistor.

→ Colour coding is also Known as Resistance Calculator

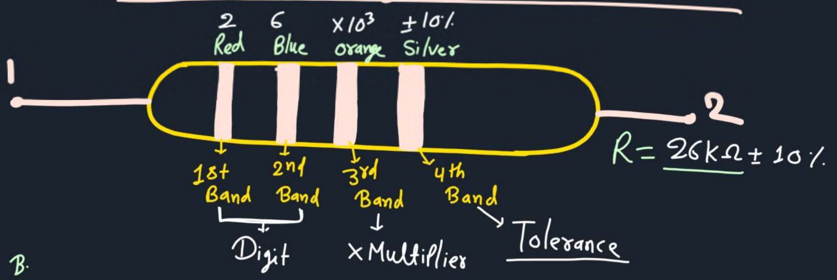
B B ROY lived in Great Britain had Very Good Wife.

	Digit	Multiplier
Black	0	$\times 10^0$
Brown	1	$\times 10^1$
Red	2	$\times 10^2$
Oranage	3	$\times 10^3$
Yellow	4	$\times 10^4$
Green	5	$\times 10^5$
Blue	6	$\times 10^6$
Violet	7	$\times 10^7$
Gray	8	$\times 10^8$
White	9	$\times 10^9$

Tolerance

Gold → ± 5%
Silver → ± 10%
None → ± 20%

We are taking 4 Band Resistor.



$R = 26k\Omega \pm 10\%$

B.
B.
R.
O.
Y

$26 \times 10^3 \Omega \pm 10\%$

$26k\Omega \pm 10\%$

Calculate the Value of Resistance for 4 Band Resistor

①Q:– Red, Yellow, Green and Gold

$2 \quad 4 \quad \times \quad 10^5 \pm 5\%$

$10^3\Omega = 1k\Omega$

$10^6\Omega = 1M\Omega$

$24 \times 10^5 \Omega \pm 5\%$

$2.4 \times 10^5 \times \frac{10}{1\cancel{0}} \Omega \pm 5\%$

$2.4 \times 10^6 \Omega \pm 5\%$

$2.4\ M\Omega \pm 5\%$

$24 \times 10^5 \Omega\ (\pm 5\%)$

$24 \times 10^5 \times \frac{10}{10} \Omega$

$\frac{24 \times 10^6}{1\cancel{0}} = 2.4 \times 10^6 \Omega$

$= 2.4M\Omega$

Q $430\Omega \pm 10\%$

B
B

$43 \times 10^1 \pm 10\%$

Yellow orange Brown Silver

①Q:- Red, Brown, Yellow, None

②Q:- Blue, Red, Green, Gold

③Q :- Violet, White, Red, Silver

④Q:- Gray, Yellow, Orange, Gold

⑤Q:- Orange, Red, Blue, None

Find the colour

Q 470 Ω ± 5%

Q 230 kΩ ± 10%

Q 230 Ω ± 5%

Q 470 kΩ ± 10%

Q 5.2 kΩ ± 20%

Combination of Resistors

→ Connection/Combination of resistors is a technique to Join two or more Resister together.

- There are 2 Ways of Connection of Resistor.

1) Series Connection

2) Parallel Connection

* Series Connection

→ When one terminal of Resistor is connected with terminal of new resistor.

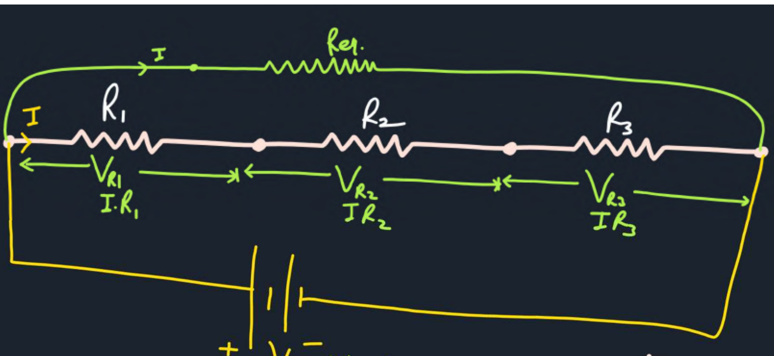
This is shown below:-

Calculation of equivalent Resistance of Series Resistor.

Series Connection

In a Series Connection, all resistors are Connected end to end and forming a Single Path for Current flow.

→ Same amount of Current flow through each resistor in Series Connection but Voltage is distributed

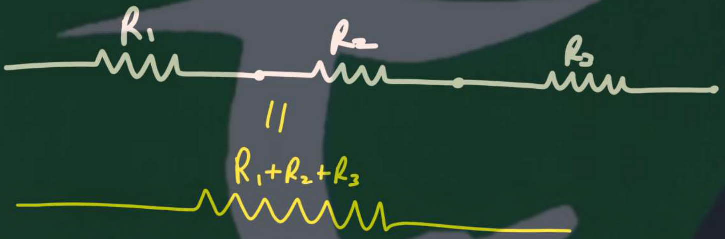


$$\underline{V} = V_{R_1} + V_{R_2} + V_{R_3}$$

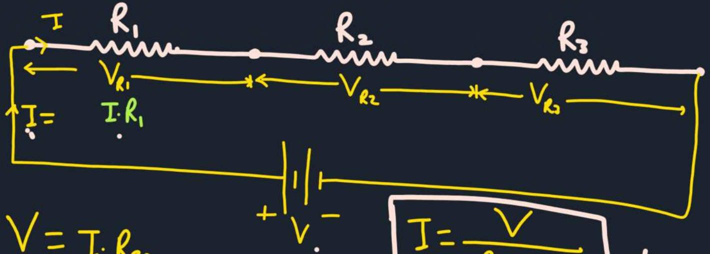
$$I R_{eq} = I.R_1 + I.R_2 + I.R_3$$

$$\cancel{I} R_{eq} = \cancel{I}(R_1 + R_2 + R_3)$$

$$\boxed{R_{eq} = R_1 + R_2 + R_3}$$



Derivation of Voltage across each resistor



$$V = I.R_{eq.}$$

$$V = I(R_1 + R_2 + R_3)$$

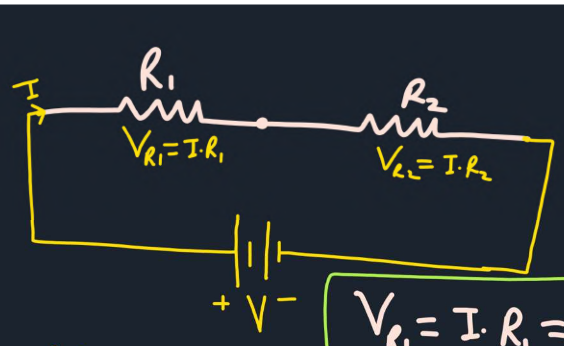
$$I = \frac{V}{R_1 + R_2 + R_3}$$

$$\boxed{I = \frac{V}{R_1 + R_2 + R_3}}$$

$$V_{R_1} = I.R_1 = \frac{V}{R_1 + R_2 + R_3} \times R_1$$

$$V_{R_2} = I.R_2 = \frac{V}{R_1 + R_2 + R_3} \times R_2$$

$$\boxed{V_{R_3} = I.R_3 = \frac{V}{R_1 + R_2 + R_3} \times R_3}$$



$$\boxed{V_{R_1} = I \cdot R_1 = \frac{V}{R_1+R_2} \times R_1}$$

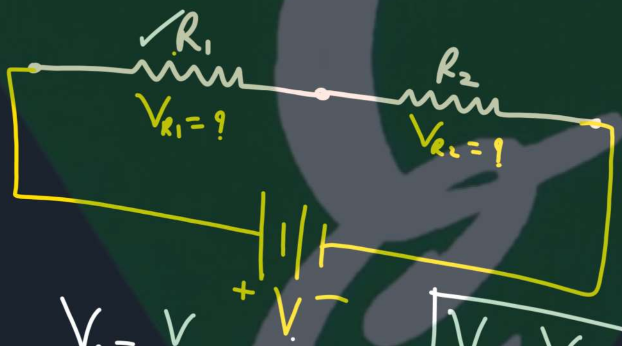
$$\boxed{V_{R_2} = I \cdot R_2 = \frac{V}{R_1+R_2} \times R_2}$$

$$V = I \cdot \underline{R_{eq}}$$

$$V = I \cdot (R_1+R_2)$$

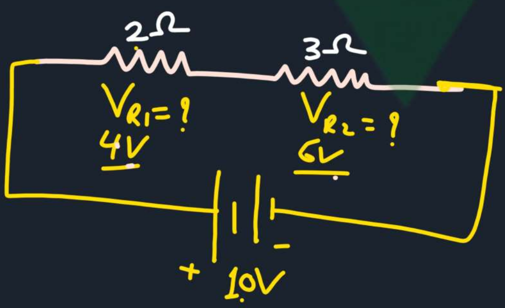
$$\boxed{I = \frac{V}{R_1+R_2}}$$

Voltage Divission Rule (VDR)



$$V_{R_1} = \frac{V}{R_1+R_2} \times R_1$$

$$\boxed{V_{R_2} = \frac{V}{R_1+R_2} \times R_2}$$



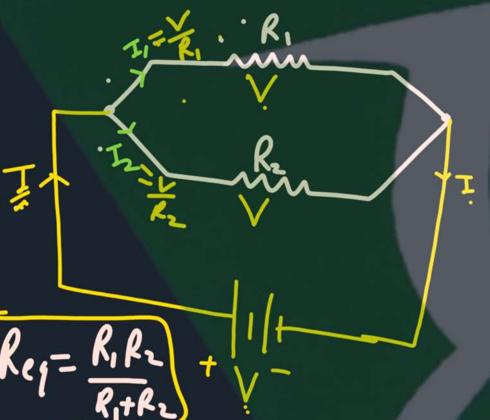
$$V_{R_1} = \frac{10}{2+3} \times 2 = \frac{\overset{2}{\cancel{10}}}{\cancel{5}} \times 2 = 4V$$

$$V_{R_2} = \frac{10}{2+3} \times 3 = \frac{\overset{2}{\cancel{10}}}{\cancel{5}} \times 3 = \underline{6V}$$

Parallel Connection of Resistor

→ In Parallel Connection, all resistors are Connected across each other, forming Exactly two sets of electrically common Point.

→ In Parallel connection Voltage across each resistor is Same but Current is divided. This is shown below:-



$$I = I_1 + I_2$$

$$\frac{V}{R_{eq}} = \frac{V}{R_1} + \frac{V}{R_2}$$

$$\cancel{V}\left(\frac{1}{R_{eq}}\right) = \cancel{V}\left(\frac{1}{R_1} + \frac{1}{R_2}\right)$$

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$\frac{1}{R_{eq}} = \frac{R_2 + R_1}{R_1 R_2}$$

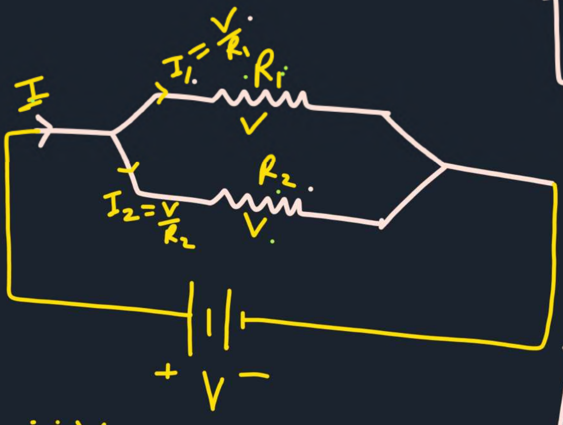
$$\boxed{R_{eq} = \frac{R_1 R_2}{R_1 + R_2}}$$

$$\boxed{R_{eq} = \frac{R_1 R_2}{R_1 + R_2}}$$

$$V = I R_{eq}.$$

$$\frac{V}{R_{eq}} = I$$

$$\boxed{R_{eq} = \frac{R_1 R_2}{R_1 + R_2}}$$



$$\boxed{V = I \cdot \frac{R_1 \cdot R_2}{R_1 + R_2}}$$

$$I_1 = \frac{V}{R_1}$$

$$I_1 = \frac{1}{R_1} \times V = \frac{1}{\cancel{R_1}} \times I \times \frac{\cancel{R_1} R_2}{R_1 + R_2}$$

$$\boxed{I_1 = \frac{I}{R_1 + R_2} \times R_2}$$

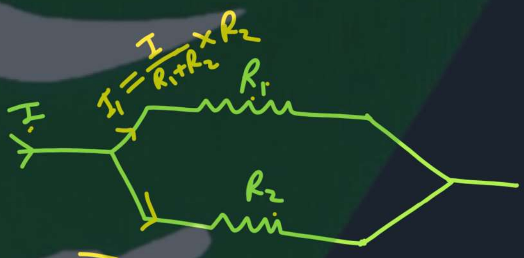
$$\because V = I \cdot R_{eq} = I \cdot \frac{R_1 \cdot R_2}{R_1 + R_2}$$

$$I_2 = \frac{V}{R_2}$$

$$I_2 = \frac{1}{R_2} \times V$$

$$I_2 = \frac{1}{\cancel{R_2}} \times I \times \frac{R_1 \cancel{R_2}}{R_1 + R_2}$$

$$\boxed{I_2 = \frac{I}{R_1 + R_2} \times R_1}$$



$$I_2 = \frac{I}{R_1 + R_2} \times R_1$$

C.D.R

$$I_1 = \frac{I}{R_1 + R_2} \times R_2 = \frac{10}{3+2} \times 2 = \frac{\cancel{10}^{2}}{\cancel{5}} \times 2 = 4A$$

$$I_2 = \frac{I}{R_1 + R_2} \times R_1 = \frac{10}{3+2} \times 3 = \frac{\cancel{10}^{2}}{\cancel{5}} \times 3 = 6A$$

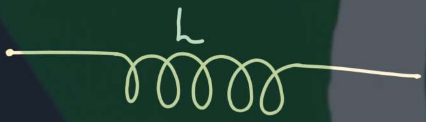
Inductor

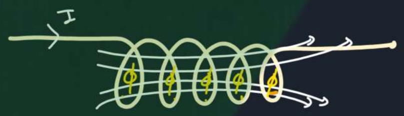
Inductor is a Passive device. It has ability to Store Energy in magnetic field as Current.

or

Inductor is a Passive device, that Stores Electrical Energy in magnetic field When Current Pass through it.

Inductor is Shown in fig given below:→

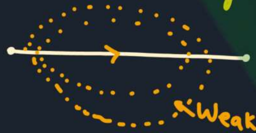




If there are N turns

$\boxed{\text{flux linkage } \psi = N \cdot \phi}$

Concept:– When Current flow in a Conductor then a magnetic field is expreinced.


Weak magnetic field

Strong Magnetic field.

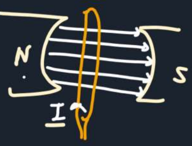
Faraday's Law of Electro Magnetic Induction.

① Magnetic field
② Conductor
③ Relative Motion

1) Faraday's 1st law:→

When Conductor Cuts magnetic line of force then E.m.f is induced in that Conductor.

$\boxed{\text{Electro Motive force}}$



2) Faraday's 2nd law:→

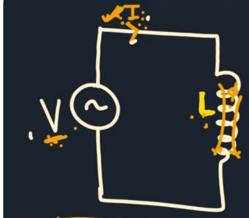
The induced E.m.f is directly Proportional to the rate of Change of flux.

i.e. $e \propto \frac{d\phi}{dt}$

$e = -N \cdot \frac{d\phi}{dt}$

$$\boxed{e = -N \cdot \frac{d\phi}{dt}}$$

Where -ve Sign Indicates Voltage opposes its Cause of Expression. It is Explained by Lenz. So It is Known as Lenz law.



$$\begin{tikzcd} V \arrow[r] & I \arrow[l, bend right, "\text{depends on}"'] \arrow[r] & \phi \arrow[l, bend right, "\text{depends on}"'] \arrow[r] & e \arrow[l, bend right, "\text{depends on}"'] \arrow[lll, dashed, bend left] \end{tikzcd}$$

Flux

$e = -N \frac{d\phi}{dt}$

$\boxed{V = L \cdot \frac{di}{dt}}$

$\boxed{V = N \cdot \frac{d\phi}{dt}}$

$\psi = N \cdot \phi$

$\phi \propto I$

$\psi \propto \phi$

$\psi \propto i$

$\boxed{\psi = L \cdot i}$

Inductance

$V = N \cdot \frac{d\phi}{dt}$

$V = \frac{d N\phi}{dt}$

$V = \frac{d\psi}{dt}$

$V = \frac{d(L \cdot i)}{dt}$

$\boxed{V = L \cdot \frac{di}{dt}}$

$\boxed{V = L \cdot \frac{di}{dt}}$ ✓

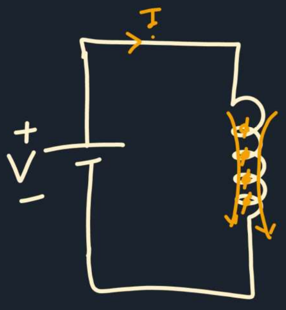
$V \cdot dt = L \cdot di$

$\frac{V}{L} dt = di$ — Integrating on both sides

$\int \frac{V}{L} \cdot dt = \int di$

$\frac{1}{L} \int V dt = i$

$\boxed{i = \frac{1}{L} \int V dt}$



$V \to I \to \phi \to \text{emf}$

$\psi = N \cdot \phi$

$\psi = Li$

$E.m.f = -N \cdot \frac{d\phi}{dt}$

$V = \frac{d N\phi}{dt}$

$V = \frac{d\psi}{dt} = \frac{d(Li)}{dt} = L \cdot \frac{di}{dt}$

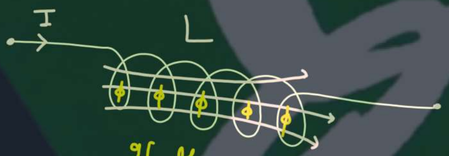
$\boxed{-V = L \cdot \frac{di}{dt}}$

$$\boxed{\begin{aligned} &\checkmark\ V = L \cdot \frac{di}{dt} \\ &\checkmark\ i = \frac{1}{L}\int v\,dt \end{aligned}}$$

याद करो

Inductor

Inductor is a passive device that stores Energy in magnetic field when current pass through it.



If there are N turns.

$$\boxed{\text{flux linkage } \psi = N \cdot \phi}$$

$$\begin{tikzcd} V \arrow[r] & I \arrow[l, bend right, "\text{depends on}"'] \arrow[r] & \phi \arrow[l, bend right, "\text{depends on}"'] \arrow[r] & \varepsilon \arrow[l, bend right, "\text{depends on}"'] \arrow[lll, bend left] \end{tikzcd}$$

$$\varepsilon \propto \frac{d\phi}{dt}$$

$$\boxed{\varepsilon = -N\frac{d\phi}{dt}}$$

Current depends on Voltage

flux depends on current

EMF depends on flux.

$\phi \propto I$

$\psi \propto \phi$

$\psi \propto I$

$$\boxed{\psi = L \cdot I}$$

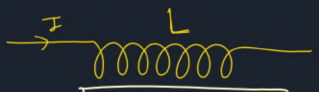
$$V = N \cdot \frac{d\phi}{dt}$$

$$V = \frac{d\,N\phi}{dt}$$

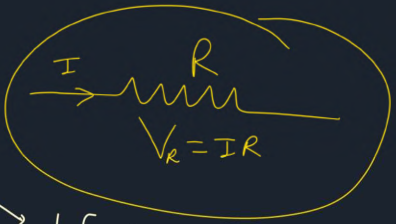
$$V = \frac{d\,\psi}{dt}$$

$$V = \frac{d(LI)}{dt}$$

$$\boxed{V = L \cdot \frac{dI}{dt}}$$



$$\boxed{V_L = L \cdot \frac{di}{dt}}$$



$V_R = IR$

$V = L \cdot \frac{di}{dt}$

$\frac{V}{L} \cdot dt = di$ → Integrating on both sides

$\int \frac{V}{L} \cdot dt = \int \underline{di}$

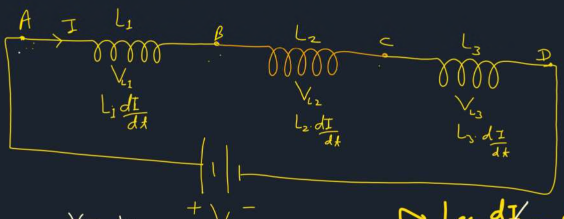
$\frac{1}{L} \int V \cdot dt = I$

$$\boxed{I = \frac{1}{L} \int V dt}$$

$$\boxed{\begin{aligned} V_L &= L \cdot \frac{di}{dt} \\ I &= \frac{1}{L} \int V dt \end{aligned}}$$ ✓

Series Connection of Inductor

- Current same
- Voltage divide



$V = V_{L1} + V_{L2} + V_{L3}$

$V_{AD} = V_{AD} + V_{DC} + V_{CD}$

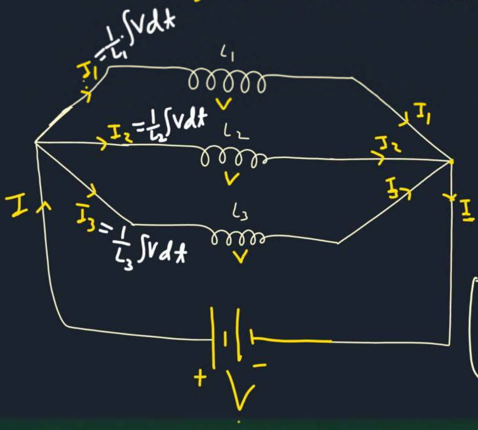
$L_{eq} \cdot \frac{dI}{dt} = L_1 \cdot \frac{dI}{dt} + L_2 \cdot \frac{dI}{dt} + L_3 \cdot \frac{dI}{dt}$

$L_{eq} \cdot \frac{\cancel{dI}}{\cancel{dt}} = \frac{\cancel{dI}}{\cancel{dt}} (L_1 + L_2 + L_3)$

$$\boxed{L_{eq} = L_1 + L_2 + L_3}$$

Parallel Connection of Inductor

↳ Voltage Same & Current distribute.



$$I = I_1 + I_2 + I_3$$

$$\frac{1}{L_{eq}}\int V dt = \frac{1}{L_1}\int V dt + \frac{1}{L_2}\int V dt + \frac{1}{L_3}\int V dt$$

$$\frac{1}{L_{eq}}\int V dt = \int V dt\left[\frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3}\right]$$

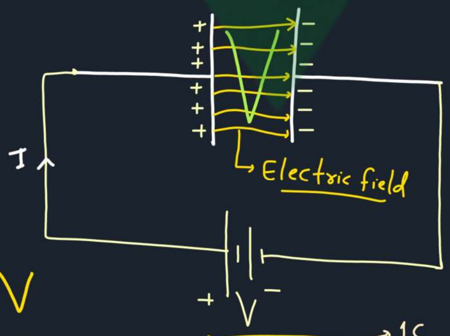
$$\boxed{\frac{1}{L_{eq}} = \frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3}}$$

Capacitor

Capacitor is a Passive device.

It has ability to Store energy in Electric field as Voltage.

The Symbol of Capacitor is shown below:→



$$\boxed{10^{-6}F = 1\,\mu F}$$

μF is mostly used as a unit.

$$Q \propto V$$

$$\boxed{Q = C.V} \text{ — ①}$$

Where Q is the Charge

C is Capacitance

V is Voltage

$$\boxed{\underset{1F}{C} = \frac{Q \rightarrow 1C}{V \rightarrow 1V}}$$

Unit of Capacitance is farad.

Farad is the larger unit.

from eq^n ①

$$\boxed{Q = CV}$$

Differentiating w.r.to time

$$\frac{dQ}{dt} = \frac{d(CV)}{dt}$$

$$\boxed{i = C\frac{dV}{dt}} \text{ — ②}$$

$$\because i = C\frac{dV}{dt}$$

$$\frac{i}{C}dt = dV$$

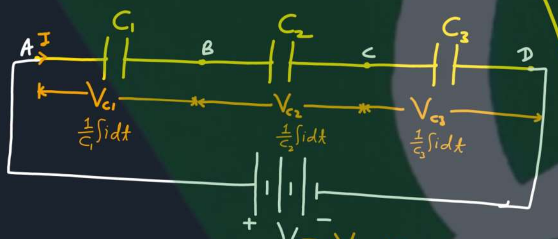
integrating on both sides:-

$$\int \frac{i}{C}dt = \int dV$$

$$\frac{1}{C}\int i\,dt = V$$

$$\boxed{V = \frac{1}{C}\int i\,dt} \text{ — ③}$$

Series Connection of Capacitor



$$V = V_{C_1} + V_{C_2} + V_{C_3}$$

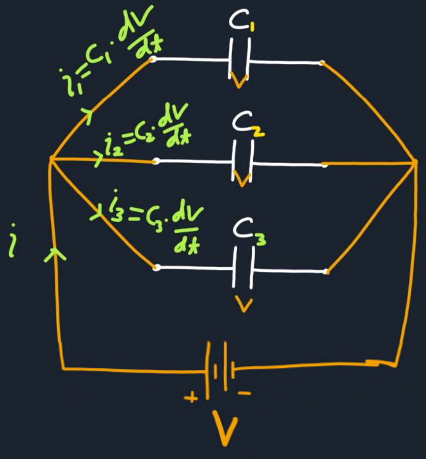
$$\frac{1}{C_{eq}}\int idt = \frac{1}{C_1}\int idt + \frac{1}{C_2}\int idt + \frac{1}{C_3}\int idt$$

$$\frac{1}{C_{eq}}\int idt = \frac{1}{C_1}\int idt + \frac{1}{C_2}\int idt + \frac{1}{C_3}\int idt$$

$$\frac{1}{C_{eq}}\cancel{\int idt} = \cancel{\int idt}\left[\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}\right]$$

$$\boxed{\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}}$$

Parallel Connection



$$i = i_1 + i_2 + i_3$$

$$C_{eq} \cdot \frac{dV}{dt} = C_1\frac{dV}{dt} + C_2\frac{dV}{dt} + C_3 \cdot \frac{dV}{dt}$$

$$C_{eq} \cdot \frac{\cancel{dV}}{\cancel{dt}} = \frac{\cancel{dV}}{\cancel{dt}}\left[C_1 + C_2 + C_3\right]$$

$$\boxed{C_{eq} = C_1 + C_2 + C_3}$$

Capacitive Reactance

→ It is the Property of Capacitor which opposes the flow of Current. It is denoted by X_c.

$$\boxed{X_c = \frac{1}{2\pi f c}}$$

Unit of X_c is ohm.

for A.C

$f = 50Hz$

$X_c = \frac{1}{2\times3.14\times50\times c} = \frac{1}{314c}$ low

Due to low reactance Capacitor allows to Pass A.C.

for D.C

$f = 0Hz$

$X_c = \frac{1}{2\times3.14\times0\times c} = \frac{1}{0} = \infty$ (High)

Due to high reactance Capacitor blocks the D.C.

Energy stored by Capacitor

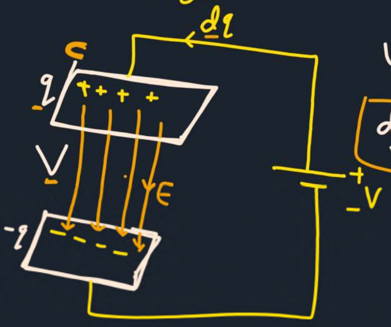
As we know that Capacitor is a passive device.

It has ability to Store energy in Electric field as Voltage.

$\because Q \propto V$

$Q = C V$

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



$v = \frac{dw}{dq}$

$\boxed{dw = v \cdot dq}$

$dw = v \cdot dq$

Integrating on both side with suitable limit

$\int dw = \int_0^{Q} v \cdot dq \quad [\because V = \frac{Q}{C}]$

$\boxed{\int x^n dx = \frac{x^{n+1}}{n+1}}$

$W = \int_0^{Q} \frac{Q}{C} \cdot dq$

$W = \frac{1}{C} \int_0^{Q} q\, dq$

$W = \frac{1}{C} \left[\frac{Q^2}{2}\right]_0^{Q} = \frac{1}{C} \left(\frac{Q^2 - 0}{2}\right)$

$W = \frac{Q^2}{2C}$

$W = \frac{1}{2} \cdot \frac{Q^2}{C} = \frac{1}{2} \times \frac{(CV)^2}{C}$

$W = \frac{1}{2} \times \frac{C^{\cancel{2}} \times V^2}{\cancel{C}}$

$\boxed{W = \frac{1}{2} CV^2}$

$\boxed{W = \frac{1}{2} C \cdot V^2}$

$W = \frac{1}{2} \times C \times \left(\frac{Q}{C}\right)^2$

$W = \frac{1}{2} \times \cancel{C} \times \frac{Q^2}{C^{\cancel{2}}}$

$\boxed{W = \frac{1}{2} \cdot \frac{Q^2}{C}}$

$\boxed{W = \frac{1}{2} Q^2/C}$

$\boxed{W = \frac{1}{2} CV^2}$

Energy stored by Capacitor is

$\boxed{\frac{1}{2} CV^2 \text{ or } \frac{1}{2} \times \frac{Q^2}{C}}$

Rough

In Capacitor

$Q = CV$

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

$dW = V \cdot dq$

$dW = \frac{Q}{C} \cdot dq$

$\int dW = \int_0^{Q} \frac{Q}{C} \cdot dq$

$W = \frac{1}{C} \left[\frac{Q^2}{2}\right]_0^{Q}$

$W = \frac{1}{2C} \times [Q^2 - 0]$

$W = \frac{1}{2C} \times Q^2$

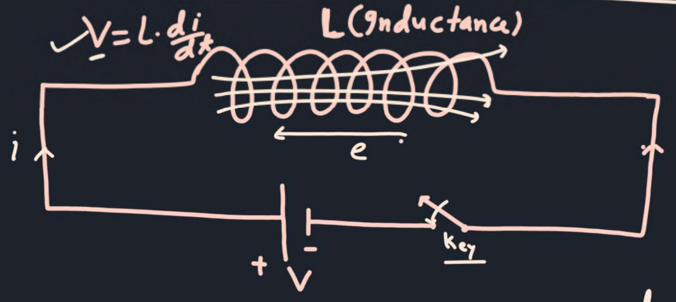
$W = \frac{1}{2C} \times [CV]^2$

$W = \frac{1}{2\cancel{C}} \times C^{\cancel{2}} V^2$

$\boxed{W = \frac{1}{2} CV^2}$

Energy Stored by Parallel Plate Capacitor is $\frac{1}{2} CV^2$

* Magnetic Energy in Inductor



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

$P = \frac{w}{t}$

$P \cdot t = w$

$\boxed{w = P \cdot t}$

$dw = P \cdot dt$

$\boxed{dw = V \cdot i \cdot dt}$

$dw = -e \times i \cdot dt$

$dw = -\left(-L \cdot \frac{di}{\cancel{dt}}\right) \cdot i \cdot \cancel{dt}$

$\boxed{dw = L \cdot i \cdot di}$

$dw = L \cdot i \cdot di$

Integrating on both sides with suitable limit.

$\int dw = \int_0^I L \cdot i \cdot di$

$\boxed{\int x^n dx = \frac{x^{n+1}}{n+1}}$

$W = L \cdot \int_0^I i \, di$

$W = L \cdot \left[\frac{I^2}{2}\right]_0^I$

$W = \frac{L}{2}\left[I^2 - 0\right]$

$W = \frac{L}{2} I^2$

$\boxed{W = \frac{1}{2} L I^2}$

Magnetic Energy in Inductor is $\frac{1}{2} L I^2$

In Capacitor	In Inductor
$\frac{1}{2} C V^2$	$\frac{1}{2} L \cdot I^2$
↓ Capacitance	↓ Inductance

Active Element:-

Element which gives energy to the circuit or Controls the flow of Signal is called Active element.

There are different types of Active Elements:-

① Energy Source ─ A) Voltage Source
   B) Current Source

② Tube device ─ A) Vacuume tube
   B) Gas Filled tube.

③ Semi Conductor device (Except Diode) like BJT, FET, OP-Amp etc.

Passive Element

An Element which doesnot generate energy is called Passive Element.

Passive element absorbs energy and then Converted into diffrent form like heat, Electric field & Magnetic field.

like:- Resistor, Capacitor, Inductor & Transformer

Linear Element

The element whose Parameters are Constant With respect to (Variation) change of Current or Voltage.

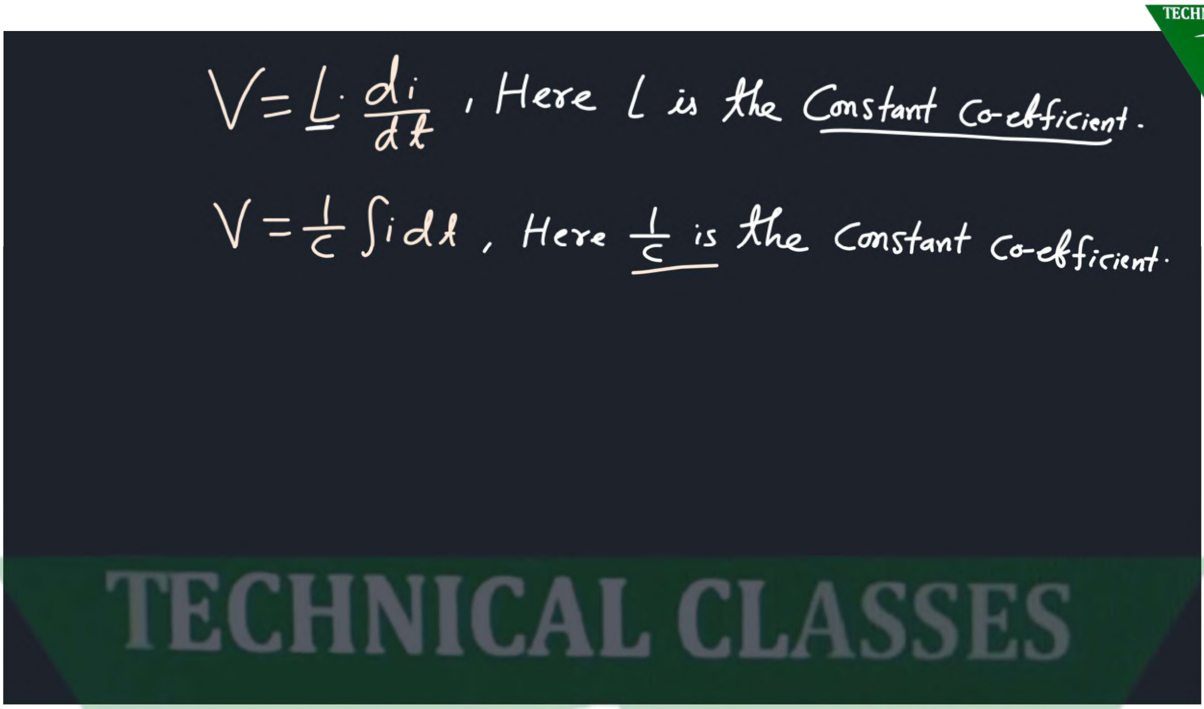
$$\boxed{\begin{array}{l} V \propto I \\ V = RI \end{array}}$$

Mathematically

If the relation between Current & Voltage Contains a Constant Co-efficient then element is linear.

Eg:- $V = RI$ (R is the Constant Co-efficient)

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



$V = \underline{L} \cdot \frac{di}{dt}$, Here L is the Constant Co-efficient.

$V = \frac{1}{c} \int i\,dt$, Here $\underline{\frac{1}{c}}$ is the Constant Co-efficient.

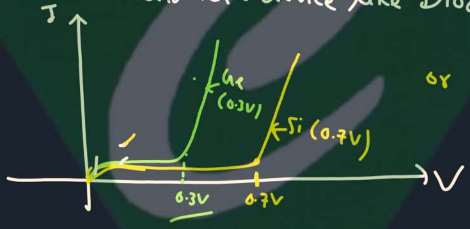
The graphical representation of linear Element:

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

Non Linear Element

The elements whose Parameter is not Constant w.r.to Voltage and Current are called non-linear elements.

Example :- Semiconductor device like Diode & Transistor



or

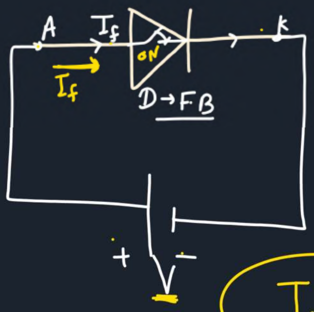
Unilateral Element

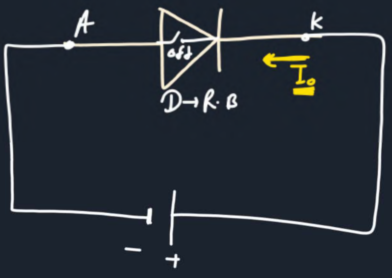
→ When elements Property and characterstics depend upon the direction of Current then Elements are Unilateral.

→ These Elements have different law of current & Voltage for different direction of Current.

Eg:- Semiconductor Device like Diode.

Diode



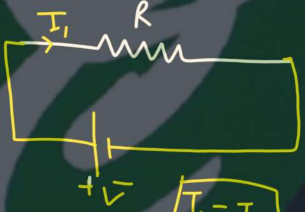


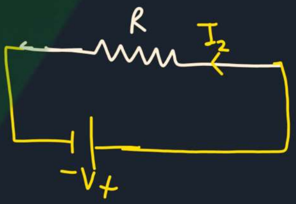
$$\boxed{I_f \neq I_o}$$

Bilateral Element

Bilateral Elements have Same relationship between Voltage & Current for Current flowing in any direction.

like Resistor





$$\boxed{I_1 = I_2}$$

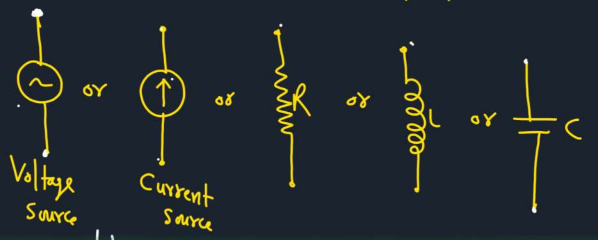
Active & Passive

Linear & Nonlinear

Unilateral & Bilateral

Improtant terms :→

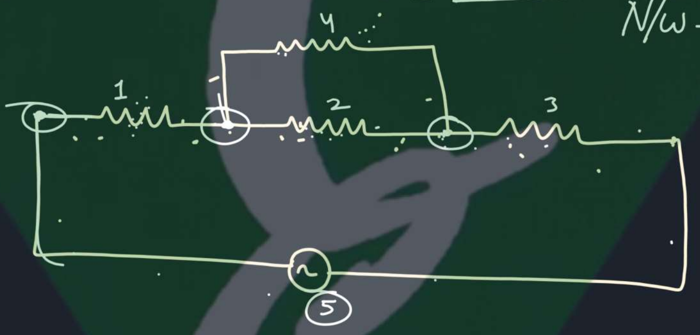
* **Branch** :→ A branch represents a Single element Such as Voltage Source, Current Source, resistor, Inductor and Capacitor.



We can Say that branch is two terminals of an Element

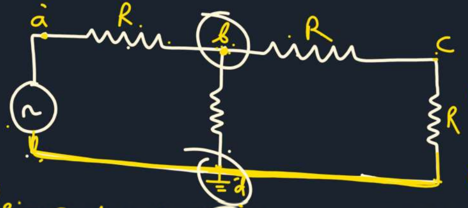
How many branches in this N/W:-

N/W → Network



Node:- The node is a Point in a network where two or more branches meet.

E.g.:-



Node:- a, b, c, d

fig-A

There are 3 types of Nodes:-

① Simple Node a, b, c,

② Datum Node (d)

③ Super Node.

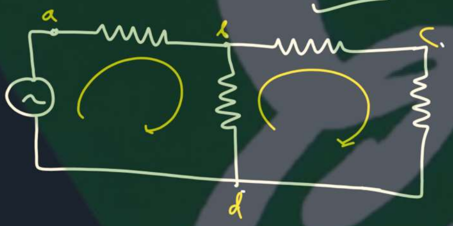
Junction :- Junction is a point where three or more branches meet together.

from fig (A)

b and d are junction.

☆ Note :- All Junctions are nodes, but all nodes are not neccessary to be a junction.

Loop :- A Close path of a Circuit in which another close path is present inside it is called loop.



a b c d a

Ohm's law

- **Current Density** → Current flow per unit Area is called Current density.

It is denoted by J. $\boxed{J=\frac{I}{A}}$

- **Electric field Intensity** :- Voltage develope per unit length is called Electric field Intensity.

$$\boxed{E=\frac{V}{l}}$$

Ohm's law

At Constant temperature and Pressure Current density is directly Proportional to Electric field Intensity.

i.e $J \alpha E$

$$\boxed{J = \sigma E}$$

$$\frac{I}{A} = \sigma \frac{V}{l}$$

$$\frac{l}{A} = \sigma \frac{V}{I}$$

$$\frac{1}{\sigma} \frac{l}{A} = \frac{V}{I}$$

$$\rho \frac{l}{A} = \frac{V}{I}$$

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

$$V = RI$$

→ Ohm's law is applicable for lummped and distributed Element ✓

Kirchoff's law

To Solve Electrical Circuit Kirchoff's Proposed two Statements which are Known as Kirchoff's Law.

① Kirchoff's Current Law (K.C.L)

② Kirchoff's Voltage Law (K.V.L)

Kirchoff's Current Law

Kirchoff's Current law States that algebric Sum of Current at any node is Zero.

Here Incoming Current is taken +ve while outgoing Current is taken -ve.

E.g:-

$I_1+I_2+(-I_3)+(-I_4)+(-I_5)=0$

$I_1+I_2-I_3-I_4-I_5=0$

$\underbrace{I_1+I_2}=\underbrace{I_3+I_4+I_5}$ —— ①

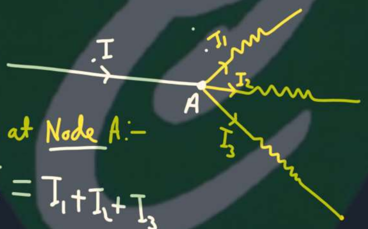
from eqn ① it is Clear that

Total Incoming Current = Total out going current

or

Sum of InComing Current = Sum of outgoing Current.

E.g:-



Apply KCL at Node A:-

$I = I_1+I_2+I_3$

$\because I = I_1+I_2+I_3$

$It = (I_1+I_2+I_3)t$

$It = I_1t+I_2t+I_3t$

$\boxed{Q = Q_1+Q_2+Q_3}$

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

$\boxed{It = Q}$

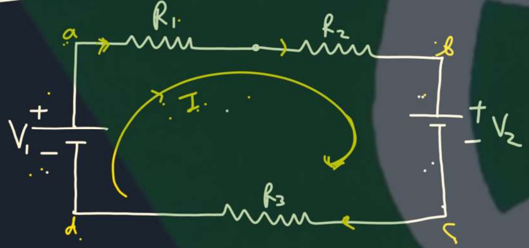
From above expression it is Very Clear that KCL Explains Conservation of Charge

② Kirchoff's Voltage Law

In any lumped network, algebric sum of Voltage is a close loope is zero.

Sign scheme:-

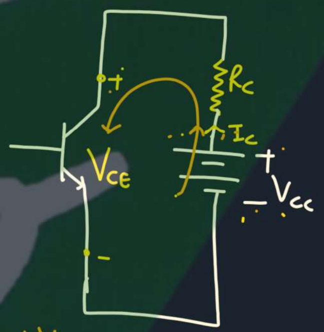
E.g:→ Apply KVL in loop a-b-c-d-a



$+V_1 - IR_1 - IR_2 - V_2 - I_3R_3$

$V_1 - V_2 = I_1R_1 + I_2R_2 + I_3R_3$

E.g.-2



$+V_{cc} - I_cR_c - V_{ce} = 0$

$$\boxed{V_{cc} - I_cR_c - V_{ce} = 0}$$

Node Analysis

- → Node analysis is a technich in which we apply K.C.L to find Voltage at particular Node.
- → Node analysis is based on K.C.L
- → It is applicable on such circuit which consists several Current sources. If a circuit consists Voltage Source then Voltage Source is Converted into Current Source. After that we apply node Analysis.

Node Analysis is also applicable in that Circuit in which number of nodes are less than number of Mesh.

In Node Analysis we use following Steps:⇒

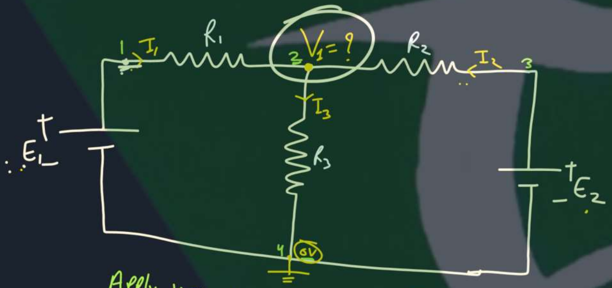
Step:-1) Identify the number of node given in a Circuit and assign their name, Such as 1, 2, 3, -- etc.

Step:-2) Assume one of the node as refrence node.

Step:-3) Assume different Branch Current as we like.

Step:-4) Write down the KCL according to Circuit.

Step:-5) Solving the given equation.



$$V_1 = \frac{\left(\frac{E_1}{R_1} + \frac{E_2}{R_1}\right)}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}}$$

Apply KCL at node 2.

$$I_1 + I_2 = I_3$$

$$\frac{E_1 - V_1}{R_1} + \frac{E_2 - V_1}{R_2} = \frac{V_1 - 0}{R_3}$$

$$\frac{E_1}{R_1} - \frac{V_1}{R_1} + \frac{E_2}{R_2} - \frac{V_1}{R_2} = \frac{V_1}{R_3}$$

$$\frac{E_1}{R_1} + \frac{E_2}{R_2} = \frac{V_1}{R_3} + \frac{V_1}{R_1} + \frac{V_1}{R_2}$$

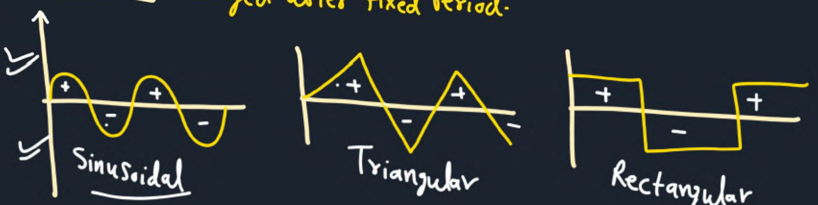
$$\frac{E_1}{R_1} + \frac{E_2}{R_2} = V_1\left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right)$$

A. C → Alternative Current

If the Value of Current or Voltage Changes Continuously or Periodically with respect to time is known as A.C.

In A.C, Polarity is changed after fixed Period.

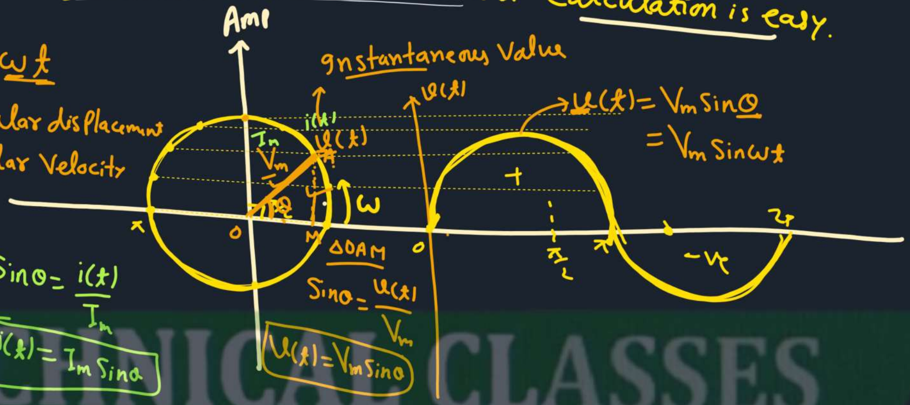
Such as:-



Sinusoidal A.C is mostly Preffered because it's generation, Transmission and Calculation is easy.

$\theta = \omega t$

θ = Angular displacement
ω = Angular Velocity
t = time



$v(t) = V_m \sin\theta$
$= V_m \sin\omega t$

$\sin\theta = \frac{i(t)}{I_m}$

$\boxed{i(t) = I_m \sin\theta}$

ΔOAM

$\sin\theta = \frac{v(t)}{V_m}$

$\boxed{v(t) = V_m \sin\theta}$

θ = Angular displacement
ω = Angular Velocity
t = time
$v(t)$ = Instantaneous Voltage

$\boxed{\theta = \omega t}$

$v(t) = V_m \sin\theta$
$= V_m \sin\omega t$

ΔOAB

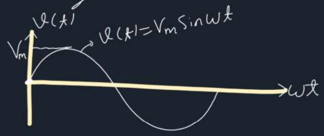
$\sin\theta = \frac{P}{H}$

$\sin\theta = \frac{v(t)}{V_m}$

$\boxed{v(t) = V_m \sin\theta}$

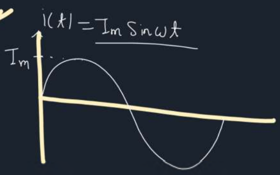
General equation of A.C Voltage is

$$\boxed{v(t) = V_m \sin\theta \quad \text{or} \quad V_m \sin\omega t}$$

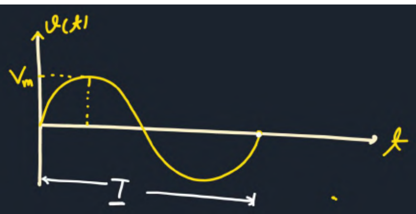


Geral equation for A.C Current

$$\boxed{i(t) = I_m \sin\theta \quad \text{or} \quad i(t) = I_m \sin\omega t}$$



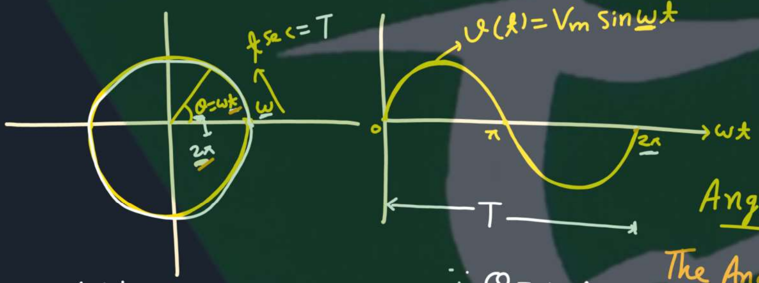
*Cycle



* **Time Periode**:– The duration in second to Complete one rotation is Called time Period. It is denoted by 'T'. It's Unit is Second.

* **Frequency**:– The No. of cycle Completed in a Second is called frequency. It is denoted by 'f'. It's Unit is Hz.

$$\boxed{f=\frac{1}{T}} \text{ or } \boxed{T=\frac{1}{f}}$$



ω is the angular Velocity

If $\theta = 2\pi$

$t = T$

$\because \theta = \omega t$

$2\pi = \omega T$

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

Angular frequency or Velocity

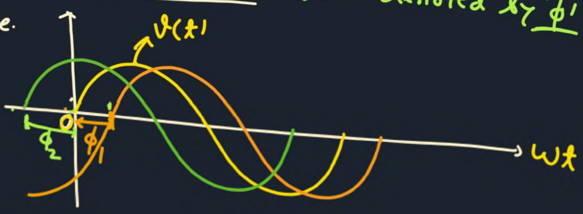
The Angular Velocity of Sinusoidal Signal is defined as the ration of Variation of angle in one cycle to the time taken to Complete one cycle.

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

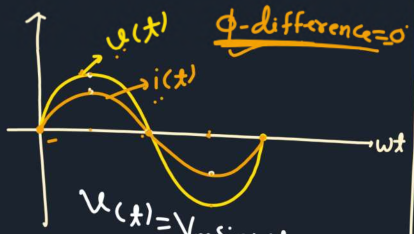
Phase

The Phase of an Alternating quantity of any instant is the time interval that has elapsed from 0 to that instant. It is denoted by 'ϕ'

i.e.



In Phase :→

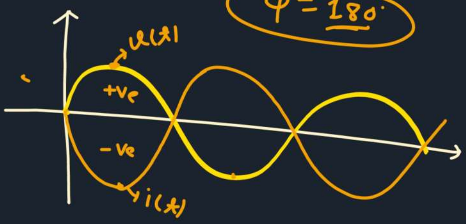


$v(t) = V_m \sin\omega t$

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

out of Phase
or
Phase Reversal

$\phi = 180^\circ$



Average Value :⇒

The average Value of A.C is Expressed by that Steady Current which transfer the Same amount of Charge as transfer in D.C for Same Condition.

It is represented as V_{avg} or I_{avg}.

$$V_{avg} = \frac{2V_m}{\pi} = 0.631 V_m$$

$$I_{avg} = \frac{2I_m}{\pi} = 0.631 I_m$$

R.M.S Value

R.M.S Value Stands of Root Means Square Value.

The R.M.S Value of A.C is that Value of Steady Current which Produces Same amount of heat as Produce D.C in Same Condition.

It is denoted by $V_{r.m.s}$ or $I_{r.m.s}$

$$\left(\begin{aligned} I_{r.m.s} &= \frac{I_m}{\sqrt{2}} = 0.707 I_m \\ V_{r.m.s} &= \frac{V_m}{\sqrt{2}} = 0.707 V_m \end{aligned} \right)$$

Maximum Value = V_m or I_m

R.M.S Value = $V_{r.m.s}$ or $I_{r.m.s}$

Average Value = V_{avg} or I_{avg}

$\frac{V_m}{V_{r.m.s}}$ = Peak factor, Creast factor or Amplitude factor

$\frac{V_{r.m.s}}{V_{avg}} = \frac{I_{r.m.s}}{I_{avg}}$ = form factor

✓Peak factor = $\frac{\text{Max. Value}}{\text{R.M.S Value}}$

✓form factor = $\frac{\text{R.M.S Value}}{\text{Average Value}}$

Peak factor :- It is defined as the ratio of Maximum Value to the r.m.s value.

It is denoted by K_p.

$$K_p = \frac{\text{Max. Value}}{\text{R.M.S Value}} = \frac{V_m}{\frac{V_m}{\sqrt{2}}} = \frac{\cancel{V_m}}{\cancel{V_m}} \times \sqrt{2} = \sqrt{2} = 1.414$$

$\boxed{K_p = 1.414}$ → for Sinusoidal signal

form factor :- It is defined as the ratio of R.M.S Value to the average value.

It is denoted by K_f.

$$K_f = \frac{\text{R.M.S Value}}{\text{Average Value}} = \frac{\frac{V_m}{\sqrt{2}}}{\frac{2V_m}{\pi}} = \frac{\cancel{V_m}}{\sqrt{2}} \times \frac{\pi}{2\cancel{V_m}} = \frac{\pi}{2\sqrt{2}} = 1.11$$

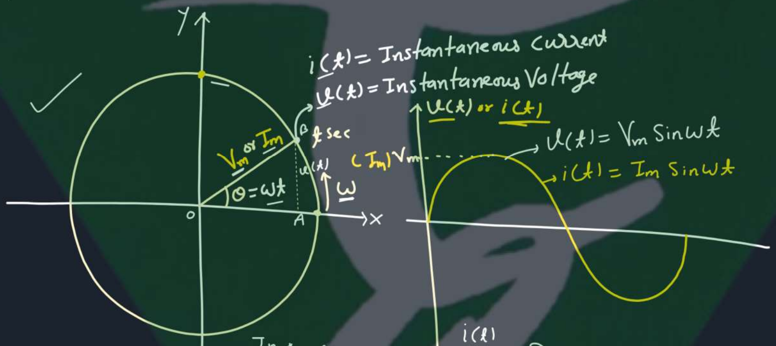
$\boxed{K_f = 1.11}$ → for Sinusoidal signal

Phashors

A Phasor is a Vector rotating at constant angular Velocity (ω).

The Sinusoidal Voltag or Current can be represented by Phasor diagram. This Phashor diagram is shown below:–

Here Phashor rotates in Counter Clock Wise :–



In △OAB:–

$$\frac{v(t)}{V_m} = \sin\theta$$

$$v(t) = V_m \sin\theta$$

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

$$\frac{i(t)}{I_m} = \sin\theta$$

$$i(t) = I_m \sin\theta$$

$$\boxed{i(t) = I_m \sin\omega t}$$

A Phashor is a Vector that represents alternating quantities like Voltage and current.

Phashors are used to analyze the A.C Circuit and determine the Phase relationship.

For Mathematical Calculation of alternating quantities we draw Phashor diagram

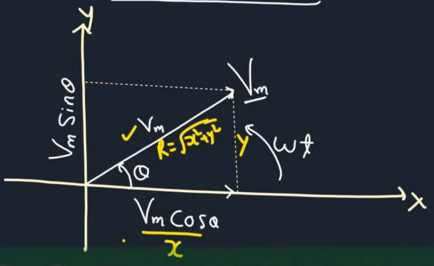
i.e. $V = V_m \sin\omega t$, $I = I_m \sin\omega t$

There are 3 types of Phasor representation:-

① Polar Form

② Rectangular Form

③ Trigonometrical form



Representation of different Phashor

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

Polar form

$V = \underline{R} \angle\phi$

✓ $\underline{R = V_m}$, ϕ is Angle.

$R = \sqrt{x^2 + y^2}$

$= \sqrt{(V_m \cos\phi)^2 + (V_m \sin\phi)^2}$

$\underline{R} = \sqrt{V_m^2 \cos^2\phi + V_m^2 \sin^2\phi} = \sqrt{V_m^2 (\underbrace{\cos^2\phi + \sin^2\phi}_{1})}$

$\boxed{R = V_m}$

Rectangular form

$V = X + iy$

or

$\boxed{V = X + jy}$

$X = V_m \cos\phi$

$Y = V_m \sin\phi$

$$\boxed{\begin{array}{c} V = V_m \cos\phi + j V_m \sin\phi \\ \text{or} \\ V_m \cos\phi - j V_m \sin\phi \end{array}}$$

* Power factor:- Power factor of A.C Circuit is $\underline{\cos\phi}$

$\boxed{\cos\phi = \frac{R}{Z}}$

E.g :- $v(t) = 10 \sin 314t$

① Amplitud or Maximum Voltage (10)

② Angular Velocity (314)

③ frequency (50Hz)

④ R.M.S Value = $0.707 V_m = 0.707 \times 10 = 7.07$

⑤ Average value = $0.636 V_m = 0.636 \times 10 = 6.36$

A, Given ⇒ $v(t) = 10 \sin 314t$ — ①

Standard equation is

$v(t) = V_m \sin \omega t$ — ②

Compare eqn ① & ②, we have :-

$V_m = 10$ (Maximum Voltage $V_m = 10$)

$\omega \cancel{t} = 314 \cancel{t}$

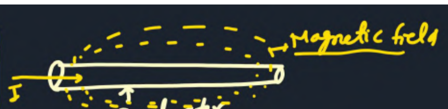
$\boxed{\omega = 314}$ (Angular Velocity = 314)

$\omega = 2\pi f = 314$

$f = \frac{314}{2\times\pi} = \frac{\cancel{314} \times \overset{50}{\cancel{100}}}{\cancel{2\times 314}} = 50Hz$

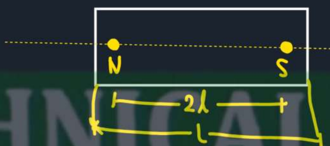
The End

Magnet



The materials which have ability to attract Small Pices of iron, Cobalt and Nickel. It has ability to Point North-South direction.

Magnetism:- The attractive and directive Property of magnet is called magnetism.



$$\boxed{\frac{2l}{L} = 0.84}$$

Important terms:-

* **Pole:-** Point of magnet at which magnetic Strength is maximum is called Pole.

There are two Poles in each magnet.
i.e. North Pole & South Pole.
Both Poles Can't be Seperated.

Magnetic Axis ⇒

A Straight line which Passes through both Poles of magnets is called Magnetic Axis.

Law of Magnetic force :-

- Like Poles repel each-other, but unlike Poles attract each-other.
- The force between two magnetic material is directly Proportional to the Product of their magnetic strength and inversly Proportimal to the Square of distance between them.

E.g.

$F \propto m_1 m_2$ — ①

$F \propto \frac{1}{d^2}$ — ②

$F \propto \frac{m_1 m_2}{d^2}$

$F = k \cdot \frac{m_1 m_2}{d^2}$

$k = \frac{1}{4\pi \mu_0 \mu_r}$

$$\boxed{F = \frac{1}{4\pi \mu_0 \mu_r} \times \frac{m_1 m_2}{r^2}}$$

μ_0 → Absolute Permibility

μ_r → Relative Permibility

$\mu_0 = 4\pi \times 10^{-7}$ H/m

Permeability

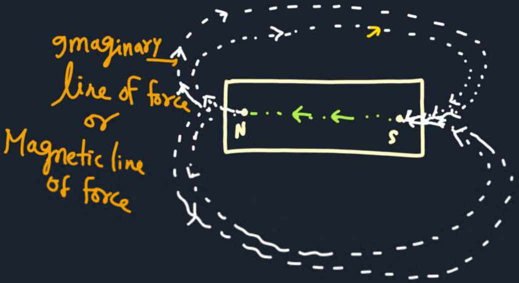
The Property of material by Virtue which it allows itself to magnetise is called Permeability. It is denoted by μ.

$$\boxed{\mu_0 = 4\pi \times 10^{-7} \text{ H/m}}$$

Absolute Permiability

Magnetic field :-

The Space or field in which magnetic Pole exferences force is called magnetic field.

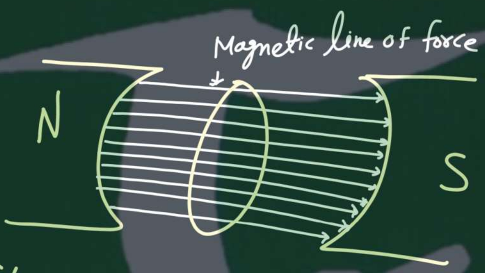


The magnetic field arround the magnet is represented by imaginary lines of forces, These line forces are magnetic line of forces.

→ Magnetic lines of force are Parallel to each-other. They never intercept.

→ Magnetic line of forces creat a close loop. Externally the direction of magnetic line of force is from North to South while internally it moves from South to North.

E.g:-



→ Magnetic flux:–

Magnetic flux represents the strength of magnetic line of force produced by magnet.

or

The number of magnetic line of forces set up by magnetic circuit is called magnetic flux. It is denoted by 'ϕ'. Its unit is Weber.

Flux density:– It is the amount of flux per unit area.

It is denoted by B.

$$\boxed{B = \frac{\phi}{A}}$$

$$\boxed{\phi = B \cdot A}$$

Magnetic flux

The magnetic flux represents the quantity of magnetic line of force set up in a magnetic circuit.

It is denoted by 'ϕ'

It's unit is Weber.

Flux density

It is defined as the amount of flux per unit Area.

It is denoted by 'B'

$$B = \frac{\phi}{A}$$

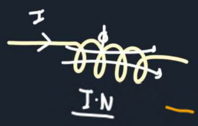
It's Unit is Weber/m^2

Magnetic motive force (m.m.f)

It is the magnetic Pressure which sets up or tends to setup magnetic flux in magnetic Circuit.

or

The Workdone in moving a Unit magnetic Pole round the magnetic Circuit is called m.m.f



Mathematically M.M.f is the Product of Current and number of turns in Coil. i.e. $\boxed{m.m.f = N \cdot I}$

It's Unit is Ampere-turns (A·T)

Resistance in Electrical ckt

Reluctance:-

The opposition that the magnetic circuit offers to magnetic flux is called reluctance

It is denoted by 'S'

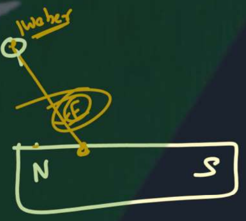
It's Unit is AT/Wb.

Permiance:- It is the reciprocal of Reluctance and measure of the ease which magnetic flux can pass through the material.

$$\text{Perminace} = \frac{1}{\text{Reluctance}}$$

It's Unit is Wb/AT

Magnetic field strength
or
Magnetic field Intensity
or
Magnetic force



It is a force which a Unit North Pole of 1 Weber Strength experence at a Particular Point in the magnetic field.

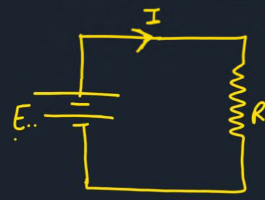
It is denoted by H.

It's Unit is N/w.

Magnetic field	Magnetic flux
① The region around the magnet where it's Pole shows the force of attraction or repulsion. It is denoted by F.	→ It is the quantity of magnetic line of forces setup in the magnetic Circuit. It is denoted by ϕ
② $F = qVB$ q = Amount of Electric Charge V = Velocity of Charge B = flux density	② $\phi = B \cdot A$ B is flux density A is Area.
③ It's Unit is Tesla	③ It's Unit is Wb.

Comparision b/w Electric circuit & Magnetic Circuit

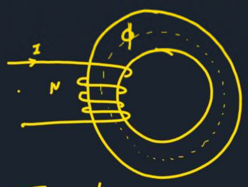
Electric ckt



$\boxed{V = IR}$

- → The Close Path for electric current is Called Electric Circuit.
- → Current $(I) = \frac{\text{E.m.f}}{\text{Resistance}} = \frac{E}{R}$
- → Unit of E.M.f is Volt
- → Current density $(J) = \frac{I}{A}$

Magnetic Ckt



$\text{M.M.f} = \phi . \underset{\downarrow}{S}.$

Reluctance

The close Path for magnetic flux is called magnetic circuit

- → Magnetic flux $\phi = \frac{\text{m.m.f}}{\text{Reluctance}}$
- → Unit of m.m.f is ampere-turn
- → flux density $(B) = \frac{\phi}{A}$.

Magnetic hysteresis

↳ Lagging

The Phenomenon of lagging of magnetic flux density (B) behind the magnetising force (H) in a magnetic material is called magnetic hysteresis.

Hysteresis loop [B-H Curve]

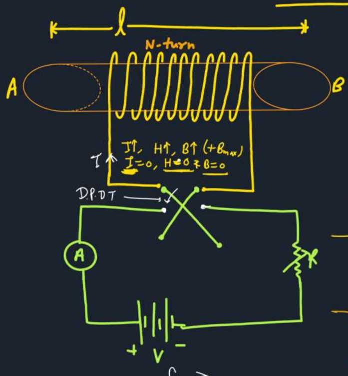


fig-①

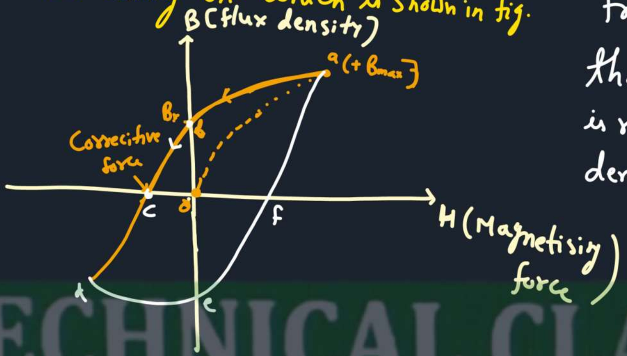
Consider as an Unmagnetised iron bar AB, Wound with Coils of N-turn. As Shown in fig-①

The magnetising force (H) Produced by this Solenoid Can be Changed by Varrying the Coil Current.

- → When Current in Solenoid is zero, then magnetising force (H=0) is zero and flux density (B=0) is also zero.
- → As Current is increased, then magnetising force is also increased and Same time flux density is also increase upto +Bmax i.e Saturated Point.

Beyond this Point flux density is not increased however we incereased magnetising force.

→ If now H is gradually reduced (by Solenoide current) It is found that magnetic flux density is not decreased along OA. Which is shown in fig.



from the fig. it is clear that when magnetising force is reduced till zero then flux density (B) is also have some value Br. That means material has residual magnetism.

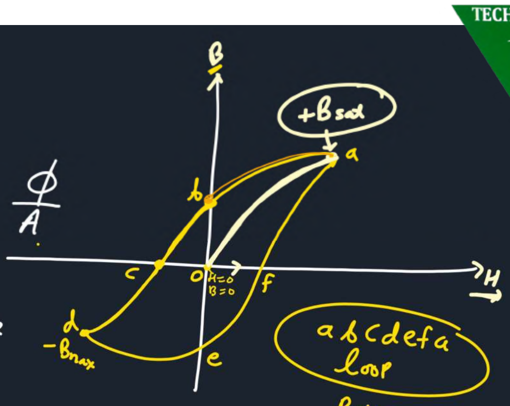
With the help [D.P.D.T] Double Pole double throat Swich we reverse the flow of current. and at Particular Value of magnetising force, residual magnetism of material is removed and flux density becomes zero.

Force at which flux density becomes zero is known as Coressive force. After reducing the magnetising force flux density reaches at $-B_{max}$ (-ve Saturation)

from the loop it is clear that B laggs behind H. This Phenomenon is magnetic hysteresis. and a loop is traced. This loop (a, b, c, d, e, f, a) is known as Hysteresis loop or B-H curve.

B → flux density = $\frac{\phi}{A}$

H → Magnetising force



Phenomenon of lagging of magnetic flux density (B) behind the magnetising force (H)

Concept

E.m.f $\propto \frac{d\phi}{dt}$

$\phi \propto I$

$\boxed{\phi = L \cdot I}$

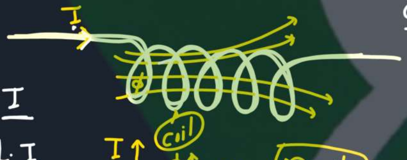
$\frac{d\phi}{dt} = E.m.f = V$

$V = L \cdot \frac{di}{dt}$

$\boxed{\frac{V}{\frac{di}{dt}} = L}$

If $\frac{di}{dt} = 1$

$\boxed{L = V}$



$\phi \propto I$

$\phi = L \cdot I$

$\frac{d\phi}{dt} = E.m.f = V$

$V = \frac{d\phi}{dt} = \frac{d(LI)}{dt}$

$I\uparrow, \phi\uparrow, B\uparrow$ $\boxed{\uparrow B = \frac{\phi\uparrow}{A}}$

$V = \frac{d\phi}{dt} = \frac{d(L \cdot i)}{dt}$

$V = L \cdot \frac{di}{dt}$

Self Inductance $\boxed{L = \frac{V}{\frac{di}{dt}}}$

Inductance

It is the Property of Coil that opposes Change in a Current by means of energy Stored in the form of magnetic fied.

There are two types of Inductance:-

① Self Inductance

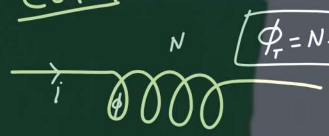
② Mutal Inductance

Self Inductance

Self Inductance is defined as the inductance of a Voltage in a Current Carrying Conductor (Wire) When the Current in the Coil itself is Changing.

In the Case of Self inductance the magnetic field is Created by a Changing Current in the Ckt itself induced Voltage in the Same Circuit.

Concept:-



$$\boxed{\phi_T = N\cdot\phi}$$

$i\uparrow,\ \phi\uparrow,\ B\uparrow$

$\because \phi \propto i$

$\phi_T \propto i$

$\phi_T = Li$

$N\cdot\phi = L\cdot i$

$$\boxed{L = \frac{N\cdot\phi}{i}}$$

Self Inductance is denoted by L.

$$\boxed{L = \frac{N\cdot\phi}{i}}$$

Where L is Self Inductance

N is the number of turns

ϕ is the flux

i is the Current.

$\phi \propto i$

$\phi = Li$

As we know that

$e.m.f \propto \frac{d\phi}{dt}$

$E.m.f = -N\frac{d\phi}{dt}\ (\because N = 1)$

$V = -\frac{d\phi}{dt}$

$V = -\frac{d\phi}{dt}$

$V = -\frac{d(L\cdot i)}{dt}$

$|V| = \left|L\cdot\frac{di}{dt}\right|$

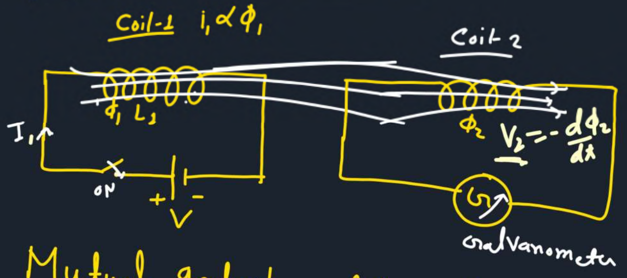
$$\boxed{L = \frac{|V|}{\left|\frac{di}{dt}\right|}}$$

✓ If, $\frac{di}{dt} = 1.$

$$\boxed{L = V}$$

☆ Self Inductance may be defined as the amount of induced Voltage When the rate of Change of Current is Unity.

Mutual Inductance ⇒



$\phi_2 \propto i_1$

$\phi_2 = M \cdot i_1$

Mutual Inductance between two Coils is defined as the Property of the Coil due to which it opposes the changes of Current in the other Coil or neighbouring Coil.

$\phi_2 \propto i_1$

$\phi_2 = M i_1$ where M is the Coefficient of mutual Inductance.

Induced e.m.f in Coil-2 is.

$$V_2 = -\frac{d(\phi_2)}{dt}$$

$$V_2 = -\frac{d(Mi_1)}{dt}$$

$$|V_2| = M\left|\frac{di_1}{dt}\right|$$

$$\boxed{M = \frac{|V_2|}{\left|\frac{di}{dt}\right|}}$$

$\because \frac{di}{dt} = 1$

$M = V_2$

Mutual Inductance of two coil is induced e.m.f of any coil when $\frac{di}{dt}$ is Unity for other coil.

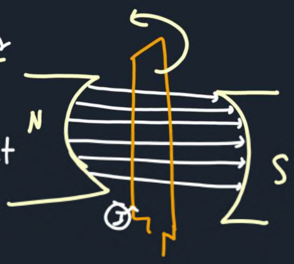
Faraday's Law of Electromagnetic Induction

Faraday's 1st law of Electromagnetic Induction:-

When a Conductor Cuts magnetic line of force an E.m.f. is induced in that Conductor

or

Whenever magnetic flux linked with a Circuit changes, induced e.m.f is Produced.



Faraday's Second law of Electromagnetic Induction:-

Faraday's Second law of Electromagnetic Induction States that the amount of induced emf is directly Proportional to the rate of Change of flux.

$$\text{E.m.f} \propto \frac{d\phi}{dt}$$

$$\boxed{\text{E.m.f} = -N\frac{d\phi}{dt}}$$ -ve Sign is Explained in Lenz's law.

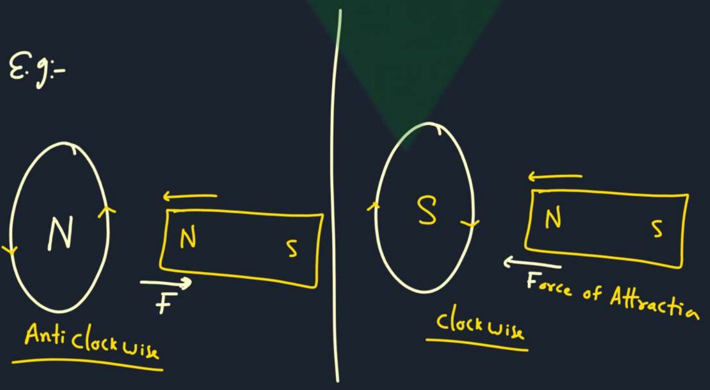
This law tells about the magnitude of Emf

→ Lenz's law:-

This law helps us to determine the direction of emf.

According to Lenz's law the Polarity of the induced e.m.f is Such that it opposes the Change in the magnetic flux responsible for it's Production.

E.g:-

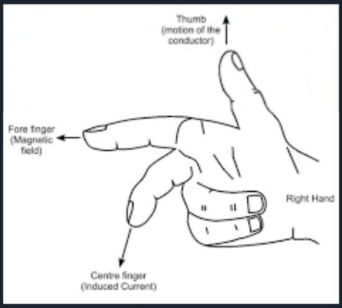


Fleming's Right hand Rule → Generator

Fleming's Left hand Rule → Motor

Fleming's Right hand Rule

Fleming's Right hand Rule is also Known as generator Rule. It helps to determine the direction of induced Current in a Conductor moving Whithin a magnetic field.



It states that, If we extend our Right hand in such a way that Thumb, fore (Index) finger and middle finger perpendicular with each other.

Thumb:– Motion of Conductor

Index finger:– Points the direction of magnetic field.

Middle finger:– Points the direction of Current Induced in Conductor

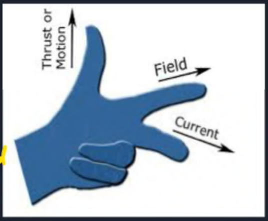
Fleming's Left hand Rule [Motor]

Fleming's Left hand rule helps to determine the direction of force of a Current Carrying Conductor Placed in magnetic field.

→Thumb:– Motion

Index finger:– Direction of Magnetic field

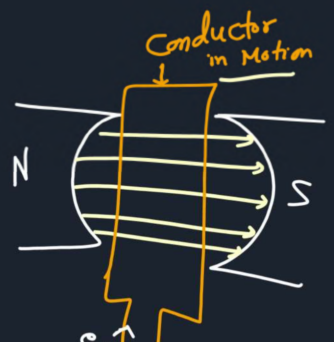
Middle finger:– Direction of current



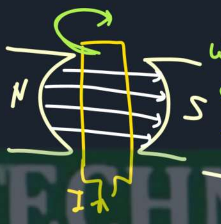
① Faraday's law
② Lenz's law
③ Fleming Right hand Rule
④ Fleming Left hand Rule
⑤ Amper's law

The End

① Magnetic field
② Conductor
③ Relative Motion



① when Conductor in Motion, Then e.m.f is Produced. (F.R.H. → Direction of induced emf or current)

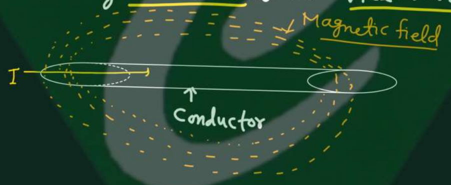


When current carrying conductor Placed in magnetic field then a force is experence in conductor → F.L.H

Ampere's law

According to Amper's law, magnetic fields are related to the electric current Produced in them.

The law specifies the magnetic field that is associated with a given current or Vice-Versa.



Mathematically

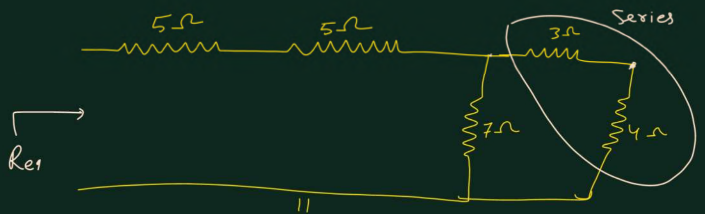
$$\boxed{\nabla \times H = \frac{\partial D}{\partial t} + J}$$

H → Magnetic field

Curl of magnetic field

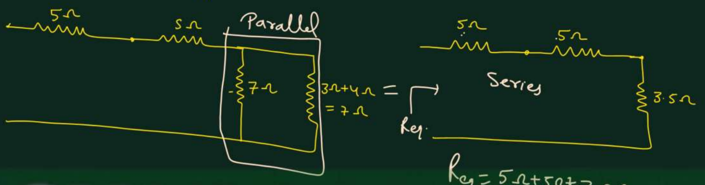
J → Current Density

Numerical



$$\frac{7\times7}{7+7}=\frac{\cancel{49}^{7}}{\cancel{14}_{2}}=3.5\Omega$$

||



$R_{eq}=5\Omega+5\Omega+3.5\Omega$

$=13.5\Omega$

The End

Roushan Sir

Aashutosh Sir

Nitesh Sir

→ Main Teacher

flow of electrons is Current

or

flow of Charges per unit time is called Current

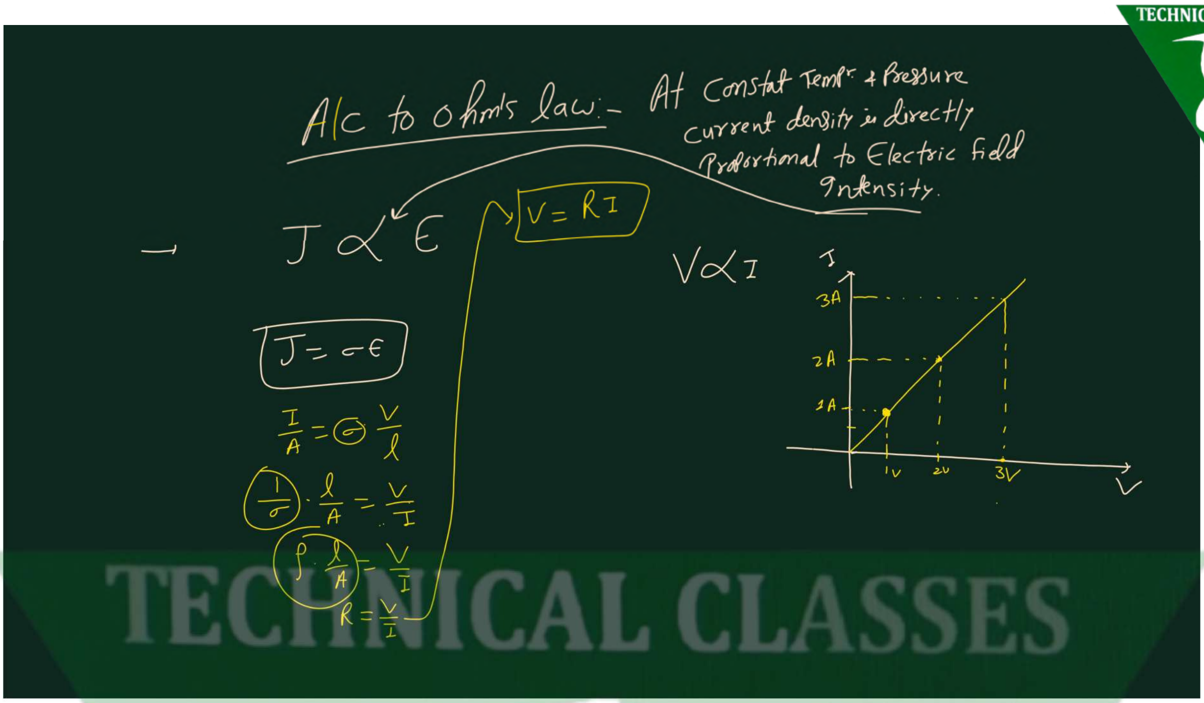
$$\boxed{J=\frac{Q}{t}}$$

* Current density(J) = Current flows per Unit Area is Called Current density

$$\boxed{J=\frac{I}{A}}$$

* Electric field Intensity (E) → Voltage developed per unit length.

$$\boxed{E=\frac{V}{l}}$$



A/c to ohm's law:- At Constat Temp^r. & Pressure current density is directly Proportional to Electric field Intensity.

$J \propto E$

$\boxed{J = \sigma E}$

$\frac{I}{A} = \sigma \frac{V}{l}$

$\frac{1}{\sigma} \cdot \frac{l}{A} = \frac{V}{I}$

$\rho \cdot \frac{l}{A} = \frac{V}{I}$

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

$\boxed{V = RI}$

$V \propto I$

Unit:-4

Basic Electronics Components

Semi Conductor

Substances which resistivity lies between Conductor and Insulator are Known as Semiconductor.

It's resistivity lies between $10^{-4}\Omega\text{-m}$ to $0.5\,\Omega\text{-m}$

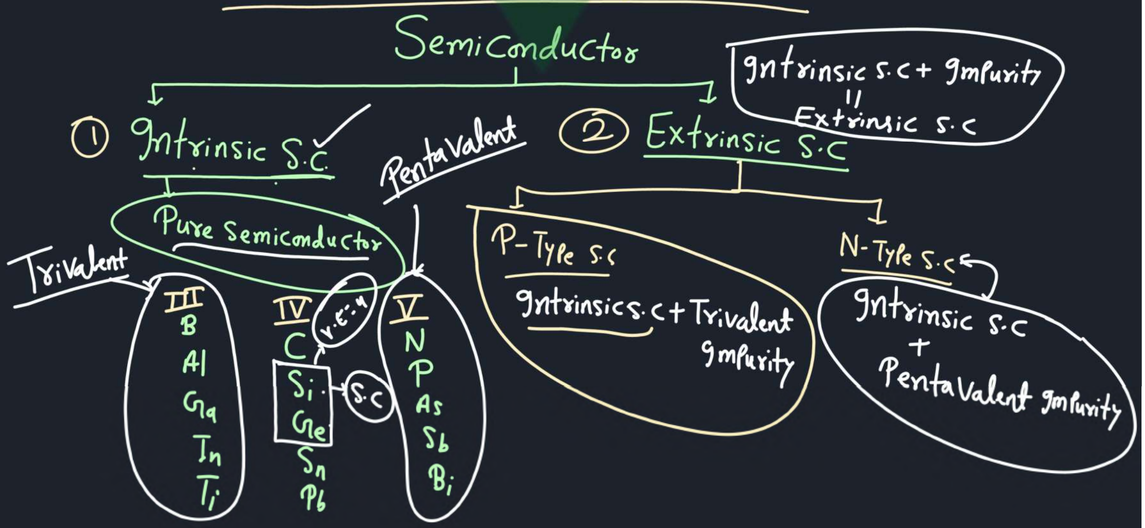
Semiconductors are magical material which resistance can be Varried by adding impurity.

So, Semiconductor material is the back bone of Electronics device.

→ Resistivity of semiconductor can also be changed by applied electric field (Connect the cell or Battery).

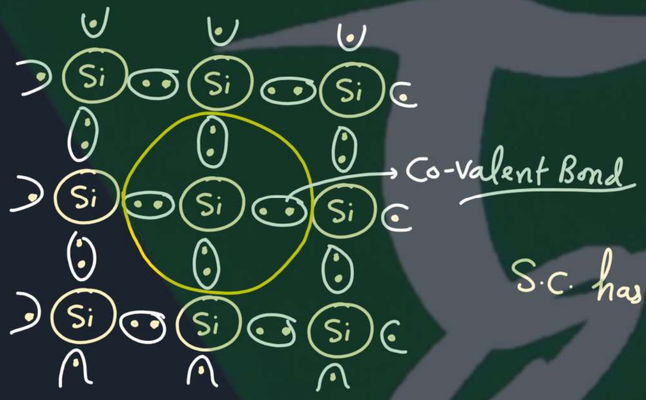
Example of Semi conductor materials:—
Silicon, Ge,

Classification of Semiconductor



Intrinsic SemiConductor

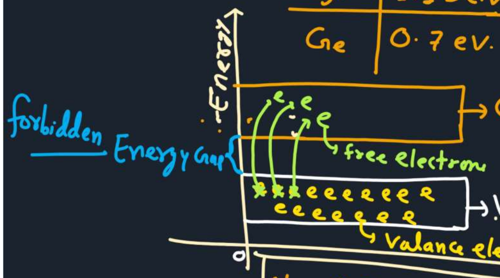
- → Purest form of SemiConductor is Known as Intrinsic Semi Conductor.
  E.g:- Pure Si & Ge
- → It's Conductivity is Very Poor. So, Extrinsic S.C is required.
- → Intrinsic S.C has 4 Valance electrons.
  The Str. of Intrinsic S.C is Shown below:-



S.C. has Co-Valent Bond..

Energy band diagram of Intrinsic S.C

	E_g at Room tem	At absolute Temp
Si	1.12 e.V	1.21 eV
Ge	0.7 eV.	0.785 eV



→ Conduction Band:- Energy Band which occupies Conduction electrons or free electectrons is Known as Conduction Band.

→ Valance Band → Energy band which occupies Valance electrons is Known as Valance Band.

$$\boxed{\text{No. of free electrons} = \text{No. of holes}}$$

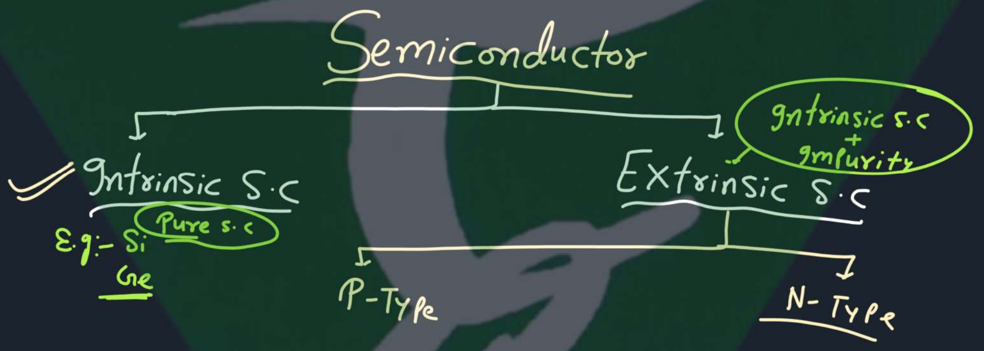
If Temperature is increased, Conductivity is also increased. Resistivity is decreased.

T ↑ R ↓

T ↓ R ↑

☆ → S.C has -ve temperature Co efficient of Resistance

☆ At Absolute temperature S.C behaves as an Insulator.



Extrinsic S.C

→ Extrinsic S.C is the Combination of Intrinsic S.C and Impurity./

→ Impurity is also Known as Doppend.

There are two types of doppent (Impurity).

① Trivalent Impurity $\overset{\text{IIIrd}}{(B, Al, Ga, In, Ti)}$

② Penta Valent Impurity $\overset{\text{Vth}}{(N, P, As, Sb, Bi)}$

→ Intrinsic S.C + Trivalent Impurity = P-Type S.C
(B, Al, Ga, In, Ti)

→ Intrinsic S.C + Pentavalent Impurity = N-Type S.C
(N, P, As, Sb, Bi)

ie. There are two types of Extrinsic S.C :⇒

① P-Type S.C →

② N-Type.

Dopping :⇒ The Process of adding Impurity is called dopping.

or

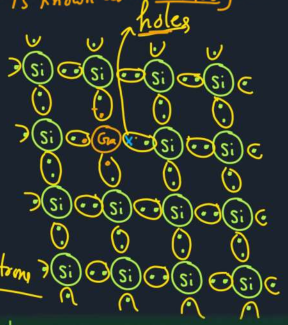
→ The Process of adding Suitable impurity in Proper manner to increase Conductivity is called Dopping.

P-Type S.C

P-Type S.C

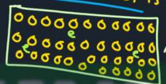
P-Type s.c is the Combination of Intrinsic s.c and trivalent Impurity. [Trivalent Impurity is known as Acceptor]

Str. of P-Type s.c is Shown below:⇒



From the Str. It is Clear that in P-Type S.c holes are Created So,

Number of holes is larger than no. of free electrons



P Type s.c

Holes – Majority

free electrons – Minority.

→ P-Type s.c is also electrically Neutral

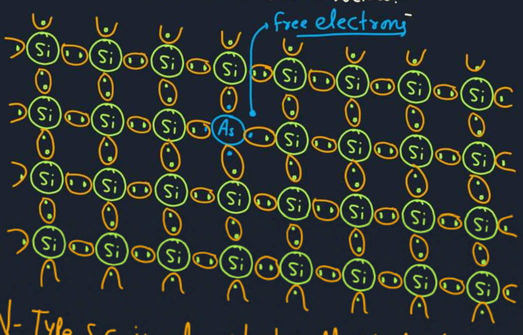
P-Type = Intrinsic S.C + Trivalent Imp.

P-Type s.c

N-Type S.C

N-Type s.c is the Combination of Intrinsic S.c and Pentavalent Impurity. [Donar]

The Str. of N-Type s.c is Shown below:–

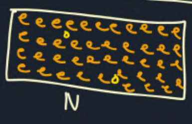


N-Type s.c is also electrically Neutral.

From the Str. it is Clear that Number of free electrons are larger than no. of holes.

Majority → free electrons

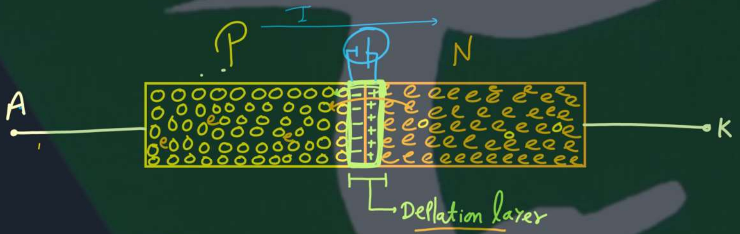
Minority → Holes.



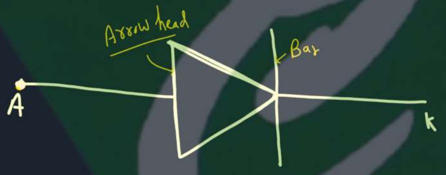
P-N-Junction Diode

When a P Type material brings near to N-Type material, then a boundry or interface is Created between both materials. This is Known as P-N Junction. P-N Junction has two terminals Anode and Cathode so It is named as P-N Junction Diode

The Schematic diagram of P-N Junction is Shown below:–



Symbol of P-N Junction diode is Shown below:⇒



→ Due to Differentent Concentration gradient Current flows in P-N Junction diode, This Current is Known as diffusion current.

→ But Main Current of diode is Drift Current.

Drift Current generates in diode due to applied Electric field

Apply Electric field means Connection of cell or Battry

→ Connection of Cell or Battery is Known as Biasing.

P-N Junction is operated in two different Baising modes.

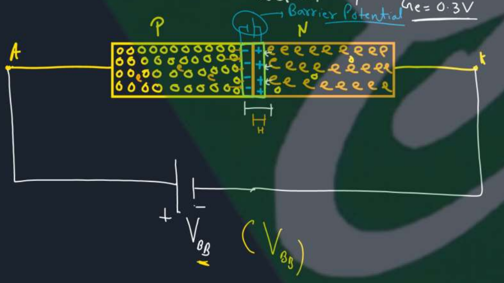
① Forward Baising

② Reverse Baising

→ Baising:- Baising is a technique to stablish electric electric field across terminals of diode for proper operation.

Forward Baising

When +ve terminal of cell is connected with P-Type material & -Ve terminal of cell is connected with N-Type material, Then P-N Junction is forward biased. The arrangement of Forward Bais is shown below:-

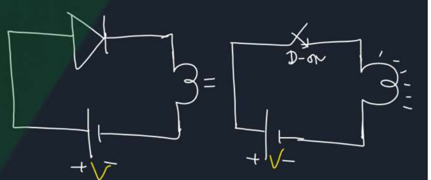


In F.B P-N Junction diode, Width of deplation layer is reduced.

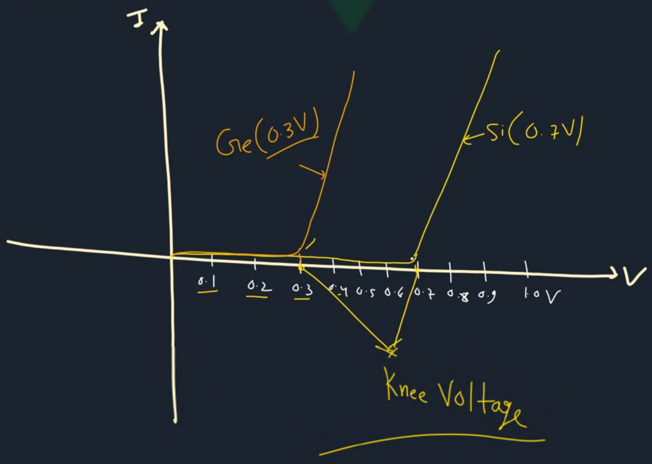
So Resistance is also reduced.

Resistance is 'few ohm'

& Diode act as ON Switch

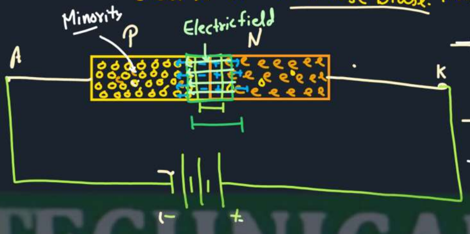


V-I Characterstics of Forward Bias P-N Junction



Reverse Biasing

When +ve terminal of battery is Connected with N-Type Material and -ve terminal of battery is Connected with P-Type material, then PN Junction diode is Said to be in Reverse Biase. This is Shown below:-

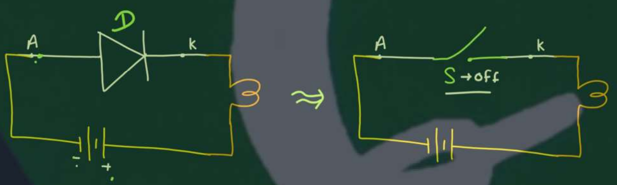


→ The width of Deplation layer is increased in R.B

→ Resistance is also increased (in MΩ)

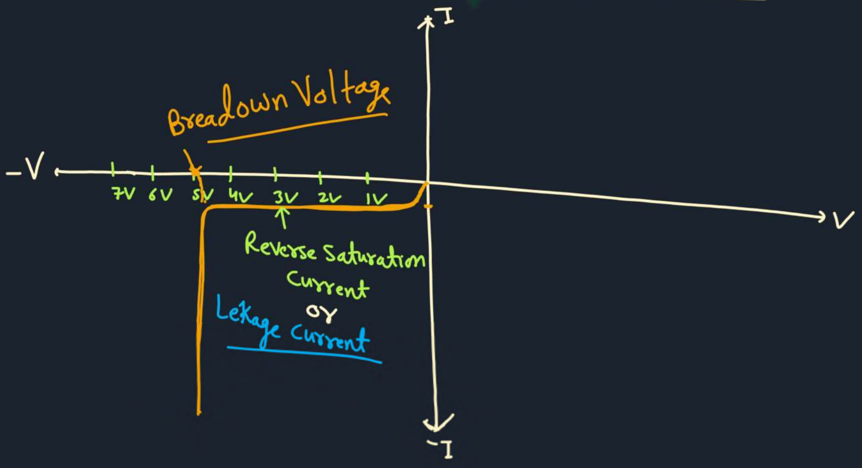
→ Due to flow of minority Charge lekage current flows. Lekage current is also known as Reverse Saturation Current.

→ Diode act as off Switch in Reverse Bias.



Note:- Diode is a Unidirectional Switch.
In F.B Diode acts as ON Switch
& In R.B Diode acts as off Switch.

V-I Characterstic of Diode in R.B



Transistor

Transfer of Resistor → Transistor

Amplifier:– A Ckt that increases the Strength of input Signal.

→ Transistor is a Solid State Electronics device in which electrical Signal transfers either from low Resistance to high Resistance or high Resistance to low Resistance.

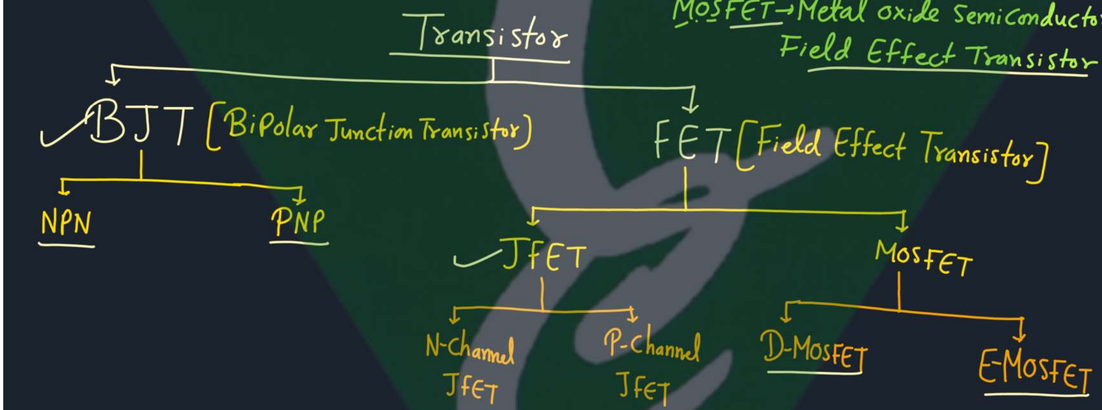
or

Transistor is a Solid State Electronic device which act as a Switch or Amplifier.

Classification of Transistor

JFET → Junction Field Effect Transistor

MOSFET → Metal oxide Semiconductor Field Effect Transistor



BJT

→ BJT Stands for Bipolar Junction Transistor.

→ When a different type of Extrinsic Semiconductor is Sandwitched between two Similar Extrinsic Semiconductor. then a BJT is formed.

① NPN Transistor ② PNP Transistor

Both are the type of BJT.

→ BJT is a three terminal semiconductor device.
It has 3 layers and 2 Junctions.

→ These layers are:-

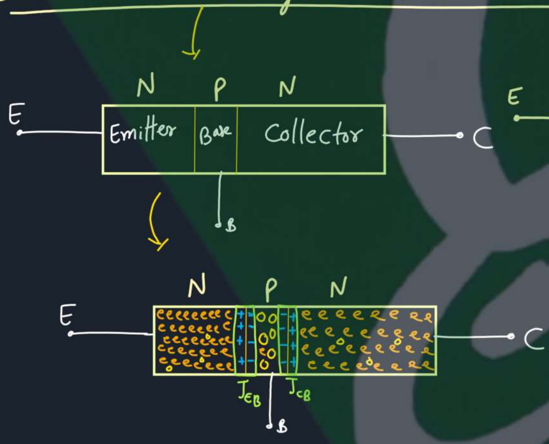
① Emitter :- Emitter is heavily dopped and moderately in size.

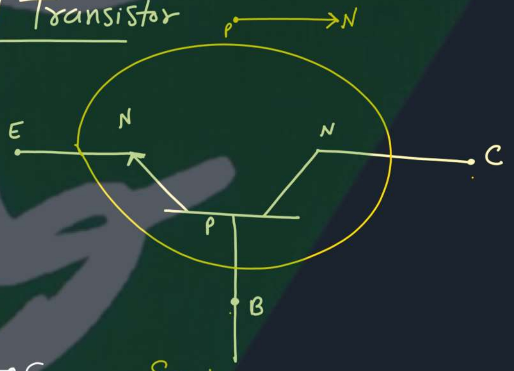
② Base :- Base is lightly dopped and Smallest in Size.

③ Collector:- Collector is moderately dopped and the largest in Size.

A/C to Dopping	A/C to Size
E>C>B	C>E>B

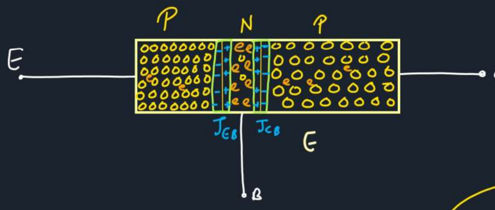
Schematic diagram of NPN Transistor



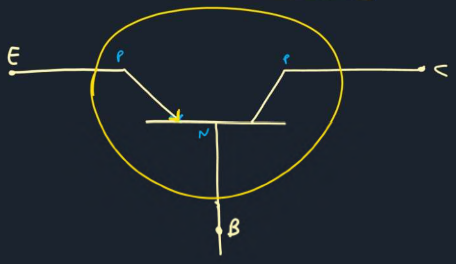


Symbol of NPN Transistor

Schematic diagram and symbol of PNP



Symbol of PNP



Operation of NPN Transistor

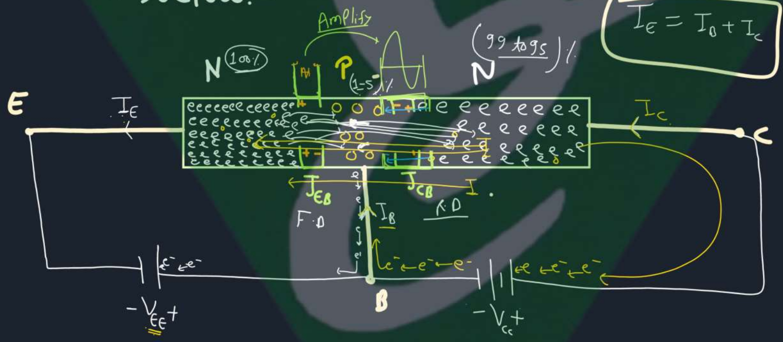
→ NPN is a type of BJT, which is formed when A Ptype material is Sandwitched between two N type material.

Generally NPN transistor is operated in Active or Normal mode. In this mode transistor acts as an amplifier.

For Active mode Input Junction is forward biased, and output Junction is Reverse biased.

The arrangement of Schematic diagram in active mode is Shown below:-

$$\boxed{I_E = I_B + I_C}$$



→ We apply forward Voltage V_{EE} across (J_{EB}) Emitter Base Junction, This Electric field (V_{EE}) breaks the Junction and due to V_{EE} Electrons of Emitter is energied to move into P-type materials. When energized electron enter into P-type material then 1 to 5% electrons are Neutrize with holes of P-type materials.

Now J_{CB} is Reverse bias with the V_{cc}, then an Electric field developed across the Junction J_B and Width of deplation is increased so Resistance is also increased.

→ This electric field supports the flow of electrons from Base to Collector side, but due to resistive effect Junction is heat up and at a particular Voltage Junction breaks. and 99 to 95% electrons are collected in collector reasons so, Current flows from Colector to Emitter layer.

$$\boxed{I_E = I_B + I_C}$$

$I_E \rightarrow mA$

$\boxed{I_B \rightarrow \mu A}$ → **Smallest**

$I_C \rightarrow mA$

Transistor

Amplifier:– A Ckt that increases the strength of input Signal.

Transfer of Resistor

↓

Transistor

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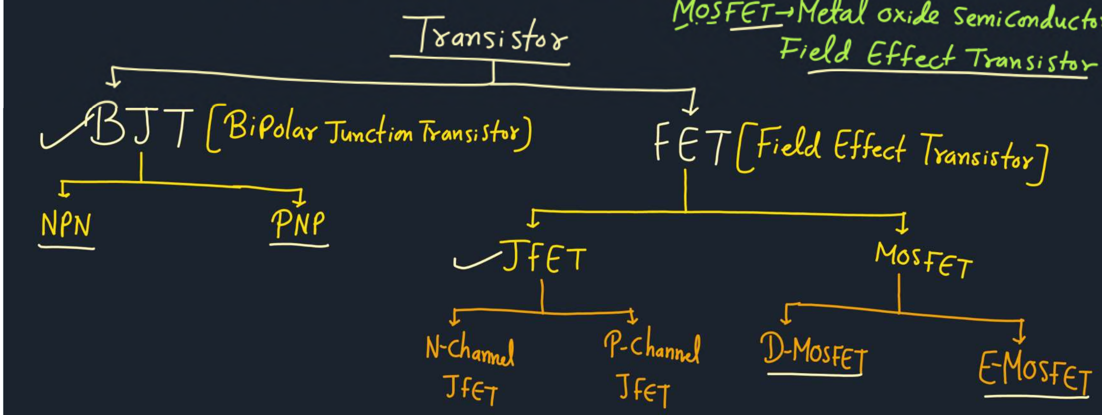

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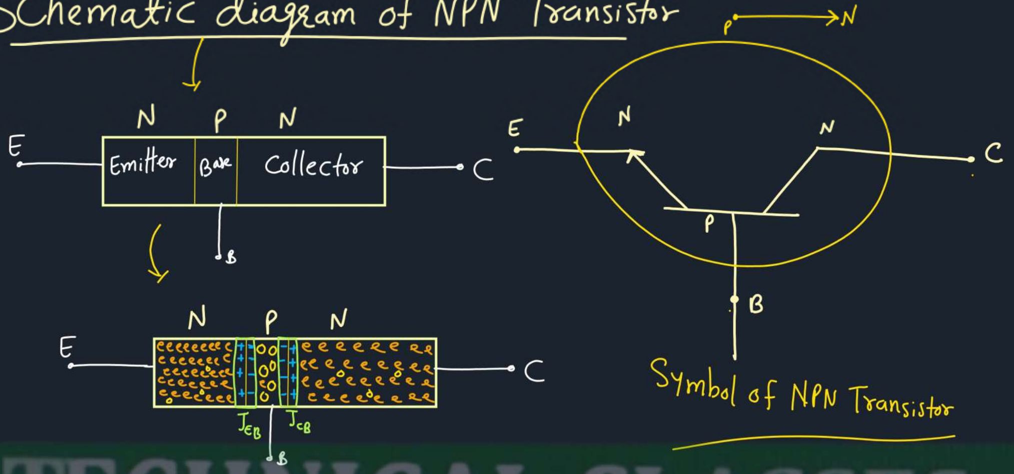
A/c to DoPPing
E>C>B

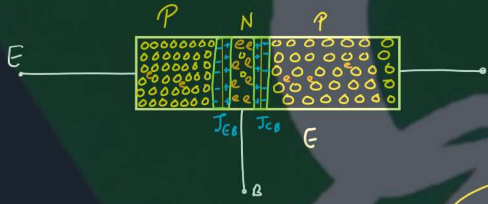
A/c to Size
C>E>B

Schematic diagram of NPN Transistor



Symbol of NPN Transistor

Schematic diagram and symbol of PNP

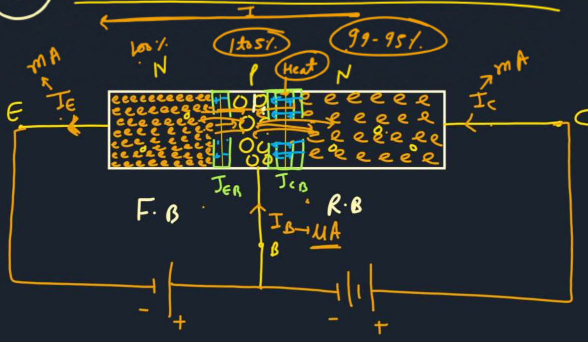


Symbol of PNP

Operation:-

I/P J_{EB}	O/P J_{CB}	Mode	Work as
F.B	F.B	Stauration Mode	ON Switch
R.B	R.B	Cut off Mode	Off Switch
✓ F.B	R.B	Active Mode or Normal Mode.	Amplifier

Operation of NPN Transistor



$$\boxed{I_E = I_B + I_C}$$

$$\boxed{\underbrace{I_E}_{O/P} = \underbrace{I_B + I_C}_{I/P}}$$

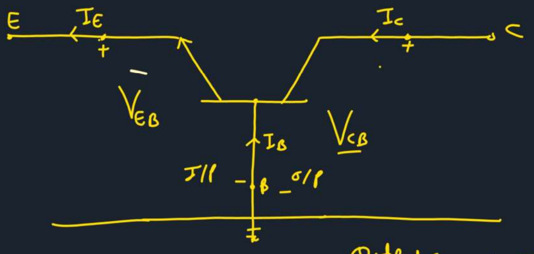
✗ Confugration of BJT

T/P → Base
O/P → Collector

There are 3 type of Confugration

① Common Base [C.B]
② Common Emitter (C.E)
③ Common Collector.

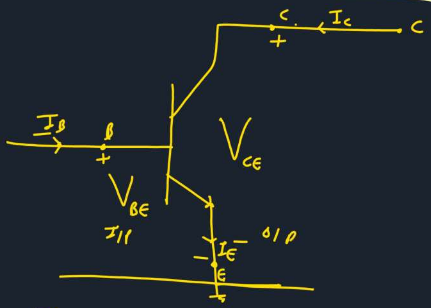
Common Base



Input Current = I_E
Input Voltage = V_{EB}

Output Current = I_C
Output Voltage V_{CB}

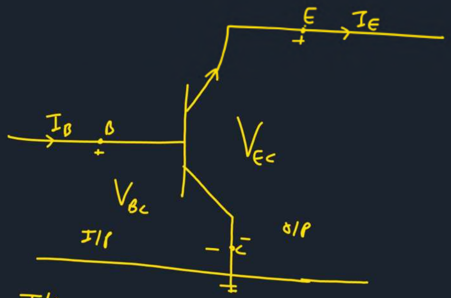
Common Emitter Connection



Input current = I_B
Input Voltage = V_{EB}

output current = I_C
output Voltage = V_{CE}

Common Collector



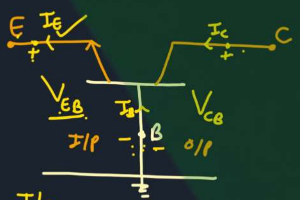
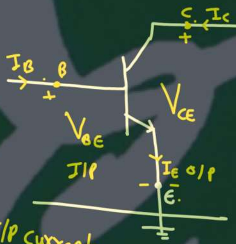
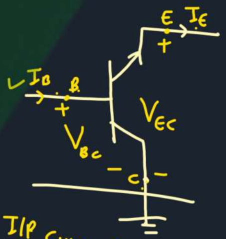
I/P Current = I_B
I/P Voltage = V_{BC}

o/P Current = I_E
o/P Voltage = V_{EC}.

JFET

Confugration of BJT

I/P → Base
o/P → collector

Parameter	C.B	C.E	C.C
Ckt	 I/P Current = I_E I/P Voltage = V_{EB} o/P Current = I_C o/P Voltage = V_{CB}	 I/P current = I_B I/P Voltage = V_{EB} o/P Current = I_C o/P Voltage = V_{CE}	 I/P Current = I_B I/P Voltage = V_{BC} o/P Current = I_E o/P Voltage = V_{EC}.

JFET

JFET Stands for Junction Field Effect Transistor.

→ It is a three terminal Semiconductor device.
It's terminals are Source, Gate & Drain.

→ It is device in which Current Conducts only due to majority Charge. So JFET is uniPolar.

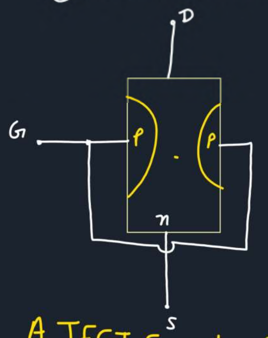
→ JFET is a Voltage Controlled device.

→ JFET has high Input Impedance.

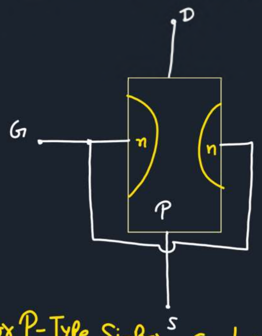
→ JFET is a Voltage Controlled Current Source device.

Construction details of JFET

① n-Channel JFET



② P-Channel JFET



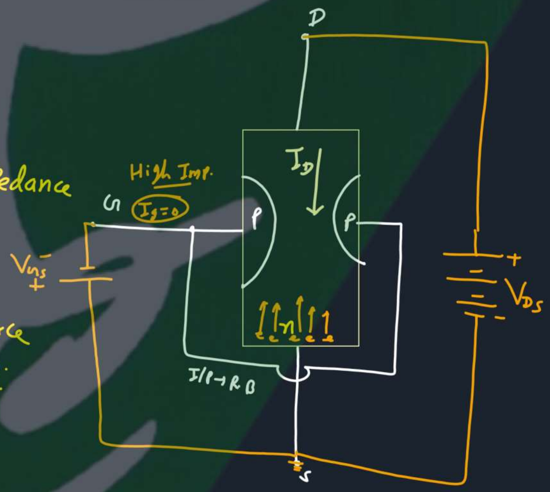
A JFET Consists of N-Type or P-Type Si-Bar Containg two P-N Junction at Side.
The bar forms the Conducting Channel for the Charge Carrier.
If bar of N-Type then n-Channel JFET & P-Type then P-Channel JFET.

JFET Polarities

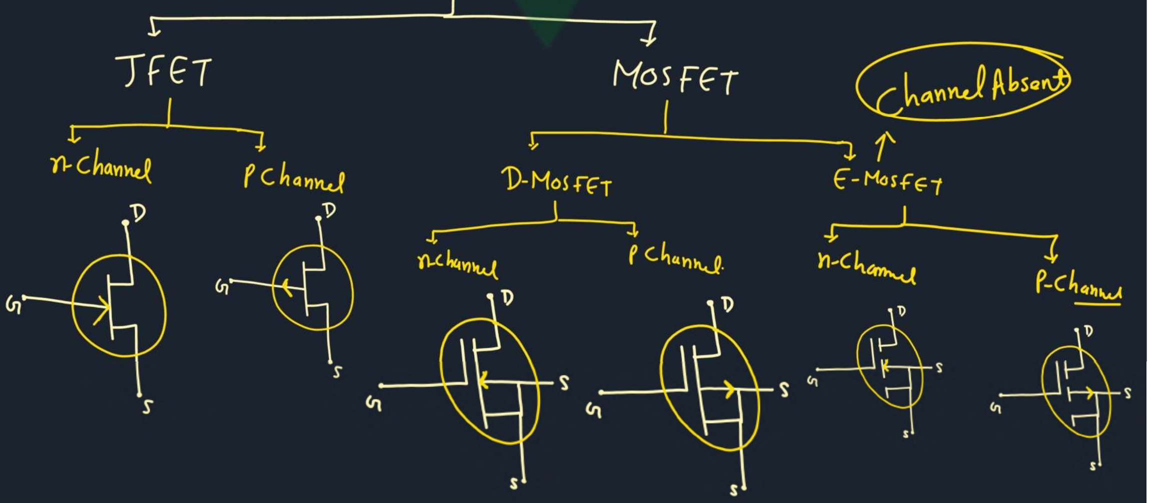
① The input circuit of JFET is Reverse Biased. So Input Impedance of JFET is high.

② The Drain is So Biased with Source that drain Current Can be flow.

③ If $I_G=0$, $I_S = I_D$



FET



Number System

A System in which Set of Symbols or digits is used is Known as number System.

There are two types of number System:-

① Non - Positional Number System

② Positional Number System

* Non Positional Number System

It is a System in which digits of it's any number have no any Place Value.

E.g:- Roman Number,

i
ii
iii
iv
v
vi
vii

* Positional Number System

It is a System in which digits of it's any number have Place Value or Weight.

E.g:- Decimal No. System

$$\underset{\text{Hundred}}{\overset{2}{\swarrow}}\ \underset{\text{Tens}}{\overset{4}{\downarrow}}\ \underset{\text{ones}}{\overset{5}{\downarrow}}$$

It is denoted as $(d_{n-1} \cdot\cdot d_2 d_1 d_0)_\gamma$

Here γ is base

→ The Value of γ is equal to the number of digits used in System.

$$\left(\underset{\gamma^{n-1}}{\overset{d_{n-1}}{\downarrow}} \cdots\cdots \underset{\gamma^{2}}{\overset{d_2}{\downarrow}}\ \underset{\gamma^{1}}{\overset{d_1}{\downarrow}}\ \underset{\gamma^{0}}{\overset{d_0}{\downarrow}}\right)_\gamma \leftarrow \text{Place Value.}$$

$\gamma \to 2$ to 36

r	Symbol
✓2	0, 1 ⟶ Binary Number System
3	0, 1, 2
4	0, 1, 2, 3
⋮	
✓8	0, 1, 2, 3, 4, 5, 6, 7 → Octal No. System
✓10	0, 1, 2, 3, 4, 5, 6, 7, 8, 9 → Decimal No. System
⋮	
✓16	0, 1, 2, 3, 4, 5, 6, 7, 8, 9, $\underset{10}{A}$, $\underset{11}{B}$, $\underset{12}{C}$, $\underset{13}{D}$, $\underset{14}{E}$, $\underset{15}{F}$

I) Conversion of any Number to Decimal Number & Vice-Versa

$$\longrightarrow \left(\underset{\times r^3}{d_3}\ \underset{\times r^2}{d_2}\ \underset{\times r^1}{d_1}\ \underset{\times r^0}{d_0}\right)_r \longrightarrow (\qquad)_{10}$$

$x_3 + x_2 + x_1 + x_0 =$ Result

E.g.:- $\left(\underset{8^2}{3}\,\underset{8^1}{2}\,\underset{8^0}{7}\right)_8 \longrightarrow (215)_{10}$

$7 \times 8^0 = 7 \times 1 = 7$

$2 \times 8^1 = 2 \times 8 = 16$

$3 \times 8^2 = 3 \times 64 = 192$

$\underline{215}$

$$\begin{array}{r|l|l} 8 & 215 & 7 \\ \hline 8 & 26 & 2 \\ \hline & 3 & \end{array}$$

$(327)_8$

$\left(\underset{6^2}{2}\,\underset{6^1}{1}\,\underset{6^0}{3}\right)_6 \rightarrow (81)_{10}$

$3 \times 6^0 = 3 \times 1 = 3$

$1 \times 6^1 = 1 \times 6 = 6$

$2 \times 6^2 = 2 \times 36 = \underline{72}$

$$\begin{array}{r|l|l} 6 & 81 & 3 \\ \hline 6 & 13 & 1 \\ \hline & 2 & \end{array}$$

$\underline{213}$

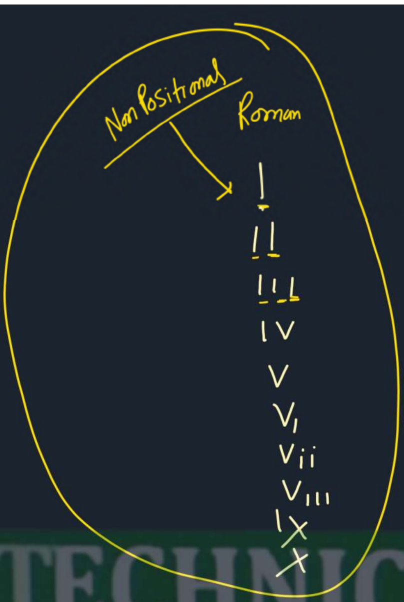
$(23A)_{16} \rightarrow (570)_{10}$

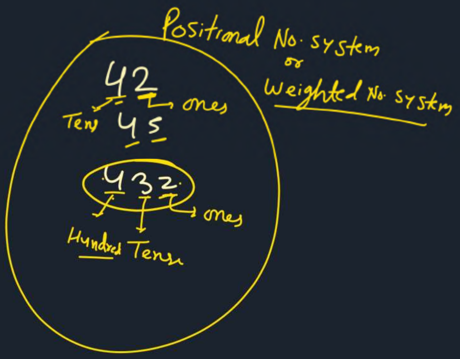
$10 \times 16^0 = 10 \times 1 = 10$

$3 \times 16^1 = 3 \times 16 = 48$

$2 \times 16^2 = 2 \times 256 = 512$

$\overline{570}$





Conversion of Any No. system to Decimal Number

$(d_{n-1} \ldots\ldots d_2 d_1 d_0)_r \rightarrow (\qquad)_{10}$

$d_0 \times r^0 = x_0$

$d_1 \times r^1 = x_1$

$d_2 \times r^2 = x_2$

$\vdots$

$d_{n-1} \times r^{n-1} = x_{n-1}$

Add = Result

✓A) Binary to Decimal

$(b_{n-1} \ldots\ldots\ldots b_2\ b_1\ b_0)_2 \rightarrow (\qquad)_{10}$

$b_0 \times 2^0 = x_0$

$b_1 \times 2^1 = x_1$

$b_2 \times 2^2 = x_2$

$\vdots$

$b_{n-1} \times 2^{n-1} = x_{n-1}$

Add = Result

E.g:- $(\overset{16}{1}\overset{8}{0}\overset{4}{1}\overset{2}{1}\overset{1}{0})_2 \rightarrow (22)_{10}$

$0 \times 2^0 = 0 = 0$

$1 \times 2^1 = 1 \times 2 = 2$

$1 \times 2^2 = 1 \times 4 = 4$

$0 \times 2^3 = 0 = 0$

$1 \times 2^4 = 1 \times 16 = 16$

Add = 22

$(\overset{32}{1}\overset{16}{1}\overset{8}{0}\overset{4}{1}\overset{2}{1}\overset{1}{0})_2 \rightarrow (54)_{10}$

$32+16+4+2 = 54$

$(\overset{8}{1}\overset{4}{1}\overset{2}{1}\overset{1}{1})_2 \rightarrow (15)_{10}$

$(\overset{32}{1}\overset{16}{0}\overset{8}{0}\overset{4}{0}\overset{2}{1}\overset{1}{0})_2 \rightarrow (34)_{10}$

B) Octal to Decimal

$(O_{n-1} \dots O_2\, O_1\, O_0)_8 \longrightarrow (\quad)_{10}$

$O_0 \times 8^0 = x_0$

$O_1 \times 8^1 = x_1$

$O_2 \times 8^2 = x_2$

$\vdots$

$O_{n-1} \times 8^{n-1} = x_{n-1}$

Add = Result

E.g:- $(217)_8 \rightarrow (143)_{10}$

2 1 7

$7 \times 8^0 = 7 \times 1 = 7$

$1 \times 8^1 = 1 \times 8 = 8$

$2 \times 8^2 = 2 \times 64 = 128$

143

$(145)_8 \rightarrow (101)_{10}$

1 4 5

$5 \times 8^0 = 5 \times 1 = 5$

$4 \times 8^1 = 4 \times 8 = 32$

$1 \times 8^2 = 1 \times 64 = 64$

101

C) Hexadecimal to Decimal

$(H_{n-1} \ldots\ldots H_2\, H_1\, H_0)_{16} \rightarrow (\qquad)_{10}$

$\rightarrow H_0 \times 16^0 = x_0$

$\rightarrow H_1 \times 16^1 = x_1$

$\rightarrow H_2 \times 16^2 = x_2$

$\vdots$

$\rightarrow H_{n-1} \times 16^{n-1} = x_n$

Add = Result

A	B	C	D	E	F
10	11	12	13	14	15

E.g:-

$(25A)_{16} \rightarrow (602)_{10}$

2 5 A

$\rightarrow 10 \times 16^0 = 10 \times 1 = 10$

$\rightarrow 5 \times 16^1 = 5 \times 16 = 80$

$\rightarrow 2 \times 16^2 = 2 \times 256 = 512$

602

✩ Conversion from Decimal to Any Number

$(d_{n-1} \ldots\ldots d_2\, d_1\, d_0)_{10} \rightarrow (\qquad)_r$

		Rem.
r	$d_{n-1} \ldots d_2\, d_1\, d_0$	r_0
r	$x_{n-1} \cdots x_2\, x_1\, x_0$	r_1
	$Y_{n-1} \ldots\ldots Y_2\, Y_1\, Y_0$	
	$\vdots$	
	r_{n-1}	

* Decimal to Binary

$(22)_{10} \rightarrow (10110)_2$

2	22	0
2	11	1
2	5	1
2	2	0
	1	

Trick:-

$(22)_{10} \rightarrow (\cancel{\frac{0}{32}}\ \frac{1}{16}\ \frac{0}{8}\ \frac{1}{4}\ \frac{1}{2}\ \frac{0}{1})_2$

20

$\cancel{\frac{0}{32}}\ \frac{1}{16}\ \frac{0}{8}\ \frac{1}{4}\ \frac{1}{2}\ \frac{0}{1}$

$(15)_{10} \rightarrow (1111)_2$

$\frac{1}{8}\ \frac{1}{4}\ \frac{1}{2}\ \frac{1}{1}$

$(54)_{10} \rightarrow (110110)_2$

$\cancel{0}\ \frac{1}{32}\ \frac{1}{16}\ \frac{0}{8}\ \frac{1}{4}\ \frac{1}{2}\ \frac{0}{1}$

48 52 54

Decimal to octal

$(d_{n-1} \ldots d_2 d_1 d_0) = (\quad)_8$

E.g:– $(143)_{10} = (217)_8$

$$\begin{array}{c|c|c} 8 & 143 & 7 \\ \hline 8 & 17 & 1 \\ \hline & 2 & \end{array}$$

$(101)_{10} \rightarrow (145)_8$

$$\begin{array}{c|c|c} 8 & 101 & 5 \\ \hline 8 & 12 & 4 \\ \hline & 1 & \end{array}$$

Decimal to Hexadecimal

$(602)_{10} \rightarrow (25A)_{16}$

$$\begin{array}{c|c|c} 16 & 602 & 10(A) \\ \hline 16 & 37 & 5 \\ \hline & 2 & \end{array}$$

$$16)\,602\,(37$$
$$\begin{array}{r} 48 \\ \hline 122 \\ 112 \\ \hline 010 \end{array}$$

* Conversion from Binary to octal & Vice Versa

$(b_{n-1} \ldots\ldots b_5 b_4 b_3 \underbrace{b_2 b_1 b_0}_{\text{3-group}})_2 \rightarrow (\quad)_8$

3-group ↓ Decimal Value

E.g:– $(\underbrace{010}_{2}\,\underbrace{110}_{6}\,\underbrace{101}_{5}\,\underbrace{100}_{4})_2 \rightarrow (2654)_8$

$(\underbrace{001}_{1}\,\underbrace{100}_{4}\,\underbrace{000}_{0}\,\underbrace{010}_{2}\,\underbrace{110}_{6}\,\underbrace{010}_{2})_2 \rightarrow (140262)_8$

$$(\underbrace{001}_{1}\,\underbrace{111}_{7}\,\underbrace{001}_{1}\,\underbrace{000}_{0}\,\underbrace{010}_{2})_2 \rightarrow (17102)_8$$

$$(\underbrace{001}_{1}\,\underbrace{010}_{2}\,\underbrace{010}_{2}\,\underbrace{110}_{6})_2 \rightarrow (1226)_8$$

OCtal to Binary

$$(1226)_8 \rightarrow (001\;010\;010\;110)_2$$

$$\frac{0}{4}\,\frac{0}{2}\,\frac{1}{1}\quad \frac{0}{4}\,\frac{1}{2}\,\frac{0}{1}\quad \frac{0}{4}\,\frac{1}{2}\,\frac{0}{1}\quad \frac{1}{4}\,\frac{1}{2}\,\frac{0}{1}$$

$$(17102)_8 \rightarrow (1111001000010)_2$$

$$\frac{0}{4}\,\frac{0}{2}\,\frac{1}{1}\quad \frac{1}{4}\,\frac{1}{2}\,\frac{1}{1}\quad \frac{0}{4}\,\frac{0}{2}\,\frac{1}{1}\quad \frac{0}{4}\,\frac{0}{2}\,\frac{0}{1}\quad \frac{0}{4}\,\frac{1}{2}\,\frac{0}{1}$$

$$(\underbrace{010}_{2}\,\underbrace{101}_{5}\,\underbrace{001}_{1})_2 \rightarrow (251)_8$$

$$(257)_8 \rightarrow (10101111)_2$$

$$010\;101\;111$$

$3 \rightarrow \frac{0}{4}\,\frac{1}{2}\,\frac{1}{1}$

$7 \rightarrow \frac{1}{4}\,\frac{1}{2}\,\frac{1}{1}$

$6 \rightarrow \frac{1}{4}\,\frac{1}{2}\,\frac{0}{1}$

	4	2	1
0 →	0	0	0
1 →	0	0	1
2 →	0	1	0
3 →	0	1	1
4 →	1	0	0
5 →	1	0	1
6 →	1	1	0
7 →	1	1	1

Binary to Hexadecimal

$$(b_{n-1} \cdots \underbrace{\cdots b_5 b_4}\ \underbrace{b_3 b_2 b_1 b_0}_{4\text{ bit}})_2 \rightarrow (\qquad)_{16}$$

$$(\underbrace{\overset{2\,1}{0011}}_{3}\,|\,\underbrace{\overset{8\,4\,2\,1}{0010}}_{2}\,|\,\underbrace{\overset{8\,4\,2\,1}{1000}}_{8}\,|\,\underbrace{\overset{8\,4\,2\,1}{0110}}_{6})_2 \rightarrow \underline{(3286)_{16}}$$

10 – A
11 – B
12 – C
13 – D
14 – E
15 – F

$$(\underbrace{\overset{8\,4\,2\,1}{0101}}_{5}\,|\,\underbrace{\overset{8\,4\,2\,1}{0001}}_{1}\,|\,\underbrace{\overset{8\,4\,2\,1}{1001}}_{9}\,|\,\underbrace{\overset{8\,4\,2\,1}{0011}}_{3}\,|\,\underbrace{\overset{8\,4\,2\,1}{1110}}_{\underset{E}{14}})_2 \rightarrow (5193E)_{16}$$

$$(\underbrace{0001}_{1}\,|\,\underbrace{1001}_{9}\,|\,\underbrace{0010}_{2}\,|\,\underbrace{0100}_{4})_2 \rightarrow \underline{(1924)_{16}}$$

$$(\underbrace{\overset{2\,1}{10}}_{2}\,|\,\underbrace{\overset{8\,4\,2\,1}{1110}}_{E}\,|\,\underbrace{\overset{8\,4\,2\,1}{0100}}_{4}\,|\,\underbrace{\overset{8\,4\,2\,1}{1010}}_{A}\,|\,\underbrace{\overset{8\,4\,2\,1}{0011}}_{3})_2 \rightarrow (2E4A3)_{16}$$

Hexadecimal to Binary

	8421
0 →	0000
1 →	0001
2 →	0010
3 →	0011
4 →	0100
5 →	0101
6 →	0110
7 →	0111
8 →	1000
9 →	1001
A →	1010
B →	1011
C →	1100
D →	1101
G →	1110
F →	1111

$$(3A2B)_{16} \rightarrow (11\,1010\,0010\,1011)_2$$

0011 1010 0010 1011

$$(57AC)_{16} \rightarrow (101011110101100)_2$$

0101 0111 1010 1100

Hexadecimal to octal

$$(\quad)_{16} \longrightarrow (\qquad)_2 \longrightarrow (\quad)_8$$

$$(57\underset{10}{A}\underset{12}{C})_{16} \rightarrow (0\underbrace{101}_{5}\underbrace{011}_{3}\underbrace{110}_{6}\underbrace{101}_{5}\underbrace{100}_{4})_2 \rightarrow (53654)_8$$

$$(3A2B)_{16} \rightarrow (00\underbrace{011}_{3}\underbrace{101}_{5}\underbrace{000}_{0}\underbrace{101}_{5}\underbrace{011}_{3})_2 \rightarrow (35053)_8$$

Octal to Hexadecimal

$$(\quad)_8 \longrightarrow (\qquad)_2 \rightarrow (\quad)_{16}$$

$$(35053)_8 \rightarrow (3A2B)_{16}$$

$$(\underbrace{0011}_{3}\underbrace{1010}_{A}\underbrace{0010}_{2}\underbrace{1011}_{B})_2$$

$$(53654)_8 \rightarrow (57AC)_{16}$$

$$(\underbrace{0101}_{5}\underbrace{0111}_{7}\underbrace{1010}_{A}\underbrace{1100}_{C})_2$$

$$(67AB)_{16} \longrightarrow (63653)_8$$

$$(0\underbrace{110}_{6}\ \underbrace{011}_{3}\underbrace{110}_{6}\underbrace{101}_{5}\underbrace{011}_{3})_2$$

H.W

$(73A8)_{16} \rightarrow (\quad)_8$

$(5763)_8 \rightarrow (\quad)_{16}$

$(2345)_8 \rightarrow (\quad)_{16}$

$(110010110)_2 \rightarrow (\quad)_8 = (\quad)_{16}$

$(11110001000)_2 \rightarrow (\quad)_8 = (\quad)_{16}$

$(217)_8 \rightarrow (\quad)_{10}$

$(275)_{10} \rightarrow (\quad)_2$

$(1010010)_2 \rightarrow (\quad)_{10}$

$(\underline{27}.\underline{75})_{10} \rightarrow (11011.11)_2$

$(27.\underline{25})_{10} \rightarrow (11011.01)_2$

$\underset{16}{1}\ \underset{8}{1}\ \underset{4}{0}\ \underset{2}{1}\ \underset{1}{1}$

$.75$
$\times 2$
$①.50 \rightarrow 1$
$\times 2$
$①.00 \rightarrow 1$

$.25$
$\times 2$
$\boxed{0}.50 \rightarrow 0$
$\times 2$
$①.00 \rightarrow 1$

$(\underline{15}.625)_{10} \rightarrow (1111.101)_2$

$15 \rightarrow 1111$

$.625$
$\times 2$
$\boxed{1}.250 \rightarrow 1$
$\times 2$
$⓪.500 \rightarrow 0$
$\times 2$
$①.000 \rightarrow 1$

$.625$
$\times 2$
$①.250 \rightarrow 1$
$\times 2$
$0.500 \rightarrow 0$
$\times 2$
$\boxed{1}.000 \rightarrow 1$

$\underline{.625 \rightarrow .101}$

$$(735.42)_8 \rightarrow (1DD.88)_{16}$$

$$\underbrace{0001}_{1}\,\underbrace{1101}_{D}\,\underbrace{1101}_{D}\,.\,\underbrace{1000}_{8}\,\underbrace{1000}_{8}$$

$$(253.75)_8 \rightarrow (AB.F4)_{16}$$

$$\underbrace{0000}_{0}\,\underbrace{1010}_{A}\,\underbrace{1011}_{B}\,.\,\underbrace{1111}_{F}\,\underbrace{0100}_{4}$$

$$(1DD.88)_{16} \rightarrow (735.42)_8 \checkmark$$

$$000\,\underbrace{111}_{7}\,\underbrace{011}_{3}\,\underbrace{101}_{5}\,.\,\underbrace{100}_{4}\,\underbrace{010}_{2}\,00$$

Q Addition

0	10	20
1	11	21
2	12	22
3	13	23
4	14	
5	15	
6	16	
7	17	
8	18	
9	1.	

$(47)_{10} + (35)_{10} = (82)_{10}$ ✓

$(57)_8 + (43)_8 = (\underline{122})_8$

$8 \,|\, 47 \,|\, 7$, 5

$8 \,|\, 35 \,|\, 3$, 4

$8 \,|\, 82 \,|\, 2$, $8 \,|\, 10 \,|\, 2$, 1

0	10	20
1	11	21
2	12	22
3	13	
4	14	
5	15	
6	16	
7	17	

$(101111)_2 + (100011)_2 = (1010010)_2$

64 · 16 · 4 2 1

```
 1 1 11
 101111
+100011
-------
1010010
```

2 → 1$\boxed{0}$

3 → 1$\boxed{1}$

$(57)_8 + (43)_8 = (122\ \ )_8$

```
 1 1 11
 101 111
+100 011
--------
001 010 010
  1   2   2
```

$\frac{1}{2}$

```
  0     0    c
 +0    +1    1  1
 --    --   +1
  0     1   10
```

```
 c
 1
   1
 + 1
 ---
 1 1
```

```
 1      1
 1      1
 -      -
 2 → 10  3 → 11
```

```
  1 1   1 1
  1 1 1 0 0 1
+ 0 1 1 0 1 1
-------------
1 0 1 0 1 0 0
```

$(1000110)_2 + (1001)_2 = (1001111\ \ )_2$

```
 1000110
+   1001
--------
 1001111
```

$(47)_8 + (32)_8 = (101)_8$

$$
\begin{array}{r}
1\,1\,1\;\;\;1\;\;\;\;\;\; \\
100\;111 \\
+\;011\;010 \\
\hline
1\;\underbrace{000}\;\underbrace{001} \\
1\;\;\;\;\;0\;\;\;\;\;1
\end{array}
$$

$(53)_8 + (35)_8 = (110)_8$

$$
\begin{array}{r}
1\,1\,1\;\;1\,1\;\; \\
101\;011 \\
+\;011\;101 \\
\hline
\underbrace{0+1}\;\underbrace{001}\;\underbrace{000} \\
1\;\;\;\;\;\;1\;\;\;\;\;\;0
\end{array}
$$

$(3A)_{16} + (47)_{16} = (81)_{16}$

$$
\begin{array}{rr}
 & 1\;1\,1\,1\;\;1\,1\;\; \\
3A \rightarrow & 0011\;1010 \\
47 \rightarrow & +\;01000111 \\
\hline
 & \underbrace{1000}\;\underbrace{0001} \\
 & 8\;\;\;\;\;\;\;\;\;1
\end{array}
$$

$(56)_{16} + (67)_{16} = (BD)_{16}$

$$
\begin{array}{r}
1\,1\;\;\; \\
0101\;0110 \\
+\;0110\;0111 \\
\hline
1011\;\;\underbrace{1101} \\
B\;\;\;\;\;\;\;13 \rightarrow D
\end{array}
$$

Complements
- → r's complement
- → (r-1)'s complement

E.g:- for Binary (r=2)
- → 2's complement
- → 1's complement

Complements are used only for Negative Number

Decimal	Sign Mag. Binary	1's Complement	2's Complement
+0	0000	0000	0000
+1	0001	0001	0001
+2	0010	0010	0010
+3	0011	0011	0011
+4	0100	0100	0100
+5	0101	0101	0101
+6	0110	0110	0110
+7	0111	0111	0111
−7	1111		
−6	1110		
−5	1101		

Rule :-

Given $(100110)_2 \xrightarrow{1's} 011001$

$(100110)_2 \xrightarrow{2's} 011010$ ✓

1's Complement:

$$\begin{array}{r} 111111 \\ -\ 100110 \\ \hline 1's\ Comp \rightarrow 011001 \end{array}$$

2's complement = 1's complement + 1

$$\begin{array}{r} 011001 \\ +\ 1 \\ \hline 011010 \end{array}$$

Binary $\xrightarrow{1's\ Complement}$

$(101001)_2 \xrightarrow{1's\ Comp} 010110$

$(100110)_2 \xrightarrow{1's\ comp} 011001$

$(11101)_2 \xrightarrow{1's\ complement} 00010$

$$\boxed{\begin{array}{r} 111111 \\ -\ 101001 \\ \hline 010110 \end{array}}$$

1's + 1 = 2's comp

$(101001)_2 \xrightarrow{2's} 010111$

$$\begin{array}{r} 010110 \\ +1 \\ \hline 010111 \end{array}$$

$(101001)_2 \longrightarrow 010111$

$(100100100)_2 \xrightarrow{2's\ comp}$ 011011100

Q Express −45 in 8 bit's 2's complement

+45 → 0 0 1 0 1 1 0 1

32 16 8 4 2 1

+45 → 00101101 $\xrightarrow{2's\ complem}$ 11010011

Q Subtract 14 from 46 Using 8 bit 2'complement Arithemetic

Ans

```
  46
 −14
 ----
 +32 ✓

  1 1 1 1 1 1
    0 0 1 0 1 1 1 0
  + 1 1 1 1 0 0 1 0
  -----------------
  1 0 0 1 0 0 0 0 0
Carry MSB
```

Ignore the carry

+14 → 0 0 0 0 1 1 1 0

↓ 2's

−14 = 11110010

MSB is 0 So Result is +ve

00100000 = +32

Q Add −75 to 26 Using 8bit 2's Complement Arithemetic

```
  26          1 1
 −75      0 0 0 1 1 0 1 0
 ----   + 1 0 1 1 0 1 0 1
 −49    -----------------
          1 1 0 0 1 1 1 1
          MSB           LSB
```

There is no Carry & MSB is 1.
So Result is −ve.

+75 → 0 1 0 0 1 0 1 1

64 32 16 8 4 2 1

↓ 2's Comp

10110101

11001111 $\xrightarrow{2's}$ 00110001

49

MSB → Most Significant bit

LSB → Least Significant bit

Find 1's & 2's complement

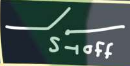
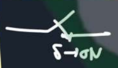
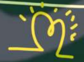
- * $(100100)_2$
- * $(111001001)_2$
- * $(1111111)_2$
- * $(100000)_2$
- * $(1010010)_2$

Logic Gate

Device which allows either Pass Signal or Stop signal according to logic is Known as logic Gate.

or

Devices which Connects load [Bulb, Fan, T.V & Motor etc] to the Source acording to Proper logic are Known as logic Gate.

logic → Condition	I/P	O/P
[No] 0	 S→off	 Bulb off [No, Bulb is not Glowing]
(Yes). 1	 S→ON	 Bulb Glows (Yes, Bulb is Glowing)

Classification of Logic Gates:-

Logic Gate

functional building Block of digital ckt is Basic logic Gate.

1) Basic Gate
   - A) NOT Gate
   - B) AND Gate
   - C) OR Gate

2) Universal Gate
   - A) NAND Gate
   - B) NoR Gate

3) Arithmetic Gate
   - A) Ex-OR
   - B) Ex-NoR

Concept:-

$$I/P \longrightarrow \boxed{\text{System}(T.f)} \longrightarrow O/P$$

$$T.f = \frac{O/P}{I/P} \quad \left(O/P = T.f \times I/P\right)$$

① NOT Gate

→ No. of I/P Pins = 1
No. of o/P Pin = 1

Definition:– Gate which Produces inverted output is called NOT Gate.

→ Symbol of NOT

T.F of NOT Gate is I → Complement

$\boxed{Y=\bar{A}}$ → Boolean Expression

— → Bar

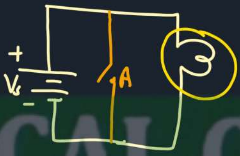
or

$\boxed{Y=A'}$

Truth Table

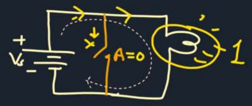
I/P A	O/P $Y=\bar{A}$
0	1
1	0

Electrical ckt

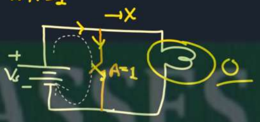


NOT Gate is also Known as inverter.

If A=0



If A=1

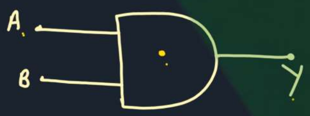


AND Gate

→ No. of I/P Pins = 2 or More
No. of o/P Pin = 1

Definition:→ A Gate which Produces high output (1) only when all inputs are high (1), otherwise low (0). is called AND Gate.

Symbol of AND Gate

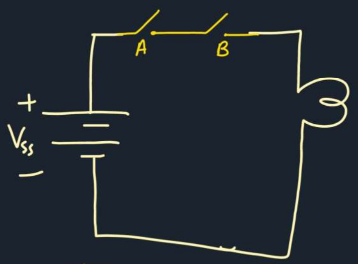


$\boxed{Y=A\cdot B}$ → Boolean Expression

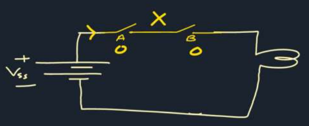
Truth Table [Total Probability of I/P = $2^{\text{No. of I/P Pins}}$]
E.g:– no of I/P Pins = 2
Total Pro = $2^2 = 4$

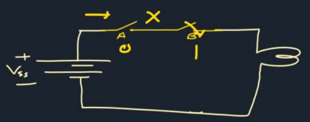
	I/P A	I/P B	O/P $Y=A\cdot B$
0	0	0	0
1	0	1	0
2	1	0	0
3	1	1	1 ✓

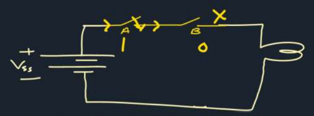
Electrical equivalent ckt:–

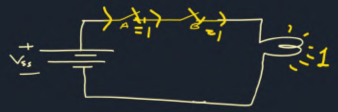


AND Gate acts as Series Switch









OR Gate ✓

No. of I/P Pins = 2 or More
No. of O/P Pin = 1
Total Probality of I/P = $2^{\text{No. of I/P Pins}}$

Defination:– A Gate which O/P is high (1) When atleast one I/P is high (1)

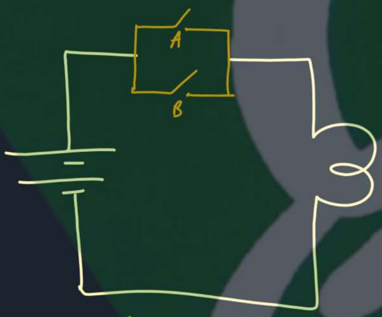
Symbol of OR Gate

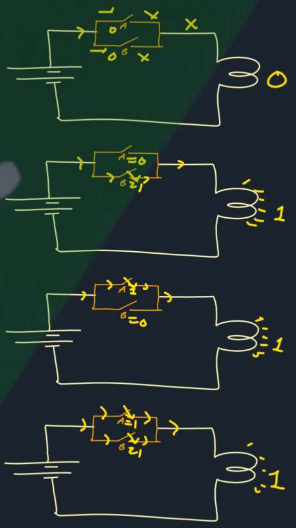
$\boxed{Y = A+B}$ – Boolean Expression

Truth Table

I/P		O/P
A	B	Y = A+B
0	0	0
0	1	1
1	0	1
1	1	1

Electrical equivalent Circuit





OR Gate acts as Parallel Switch

NAND Gate

Negation of AND

Defination:– A Gate Which O/P is high when at least one I/P is low (0).

No. of I/P Pins = 2 or More
No. of O/P Pin = 1 Pins

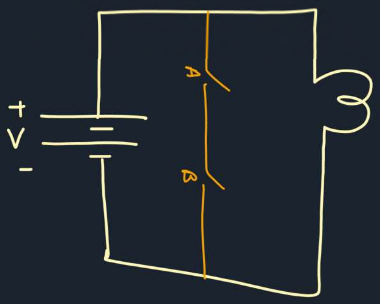
Symbol:–

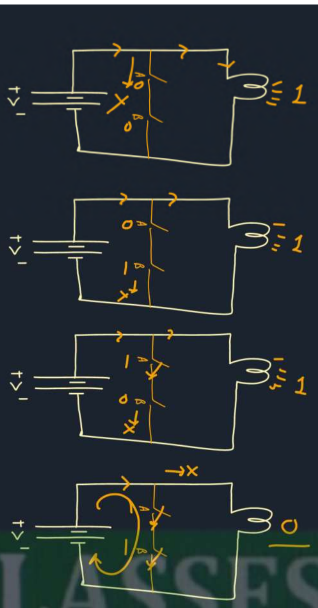
or

Truth Table

I/P		O/P
A	B	$Y = \overline{A \cdot B}$
0	0	1
0	1	1
1	0	1
1	1	0

Electrical Equivalent Ckt





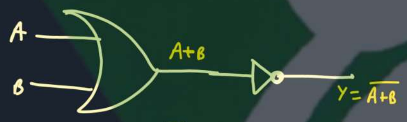
NOR Gate

Negation of OR Gate

No. of I/P Pins = 2 or More

No. of o/p Pin = 1

Symbol :-



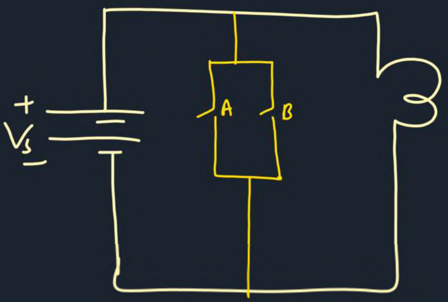
or

Defination :- A Gate which o/p is low(0) when at least one input is high(1).

Truth Table

I/P		O/P
A	B	$Y = \overline{A+B}$
0	0	1
0	1	0
1	0	0
1	1	0

Electrical equivalent ckt

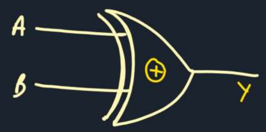


EX-OR Gate

[Anti Coincedent Gate]
or
Enequality Detector

No. of I/P Pins = 2
No. of o/P Pins = 1

Symbol



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

Defination:- A Gate whose o/P is high (1) When both inputs are different.

Truth Table

I/P		o/P
A	B	$Y = A \oplus B$
0	0	0
0	1	1
1	0	1
1	1	0

EX-NOR

No. of I/P Pins = 2
No. of o/P Pin = 1
Equality detector

Symbol

$\boxed{Y = A \odot B}$

Defination:- A Gate whose o/P is high (1) When both inputs are same.

Truth Table

I/P		o/P
A	B	$Y = A \odot B$
0	0	1.
0	1	0
1	0	0
1	1	1

Boolean Algebra

→ It is the algebra of binary Variables.

→ It is also known as two Value algebra because binary Variable have only two Values. [0 & 1]

→ It is discoverd by Jorge Boole in 1854

→ It's law & theorem Can be effectively used for Simplification of Complex Boolean expression.

1) NOT Laws:-

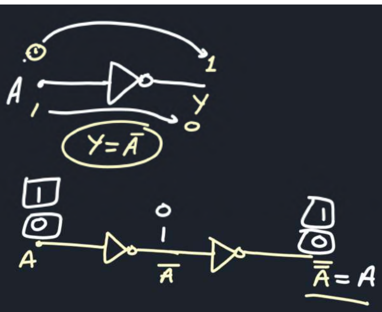
A) $\bar{0} = 1$

B) $\bar{1} = 0$

C) $\bar{\bar{A}} = A \quad [\bar{\bar{x}} = x]$

D) If $A = 0, \; \bar{A} = 1$

E) If $A = 1, \; \bar{A} = 0$



$\boxed{Y = \bar{A}}$

$\bar{\bar{A}} = A$

2) AND Law:-

A) $A \cdot 0 = 0$

B) $A \cdot 1 = A$

C) $A \cdot A = A$

D) $A \cdot \bar{A} = 0 \; (x \cdot \bar{x} = 0)$

If $A = 0, \; \bar{A} = 1 \; (0 \cdot 1 = 0)$

$A = 1, \; \bar{A} = 0 \; (1 \cdot 0 = 0)$

$\boxed{Y = A \cdot B}$

A	B	$Y = A \cdot B$
0	0	0
0	1	0
1	0	0
1	1	1

$A \cdot A = A$

OR Law ⇒

A) $A + 0 = A$

B) $A + 1 = 1$

C) $A + A = A$

$\boxed{\begin{matrix} 0 + 0 = 0 \\ 1 + 1 = 1 \end{matrix}}$

D) $A + \bar{A} = 1 \quad (x + \bar{x} = 1)$

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

$0 + 1 = 1$

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

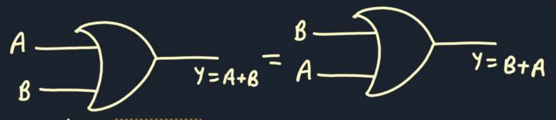
$1 + 0 = 1$

$Y = A + B$

A	B	$Y = A + B$
0	0	0
0	1	1
1	0	1
1	1	1

Commutative Law:⇒

Law:-1) $A + B = B + A$ or $A+B+C+D = D+C+A+B$



A	B	Y=A+B
0	0	0
0	1	1
1	0	1
1	1	1

B	A	Y=B+A
0	0	0
0	1	1
1	0	1
1	1	1

Law:-2) $A \cdot B = B \cdot A$ or $A \cdot B \cdot C = C \cdot A \cdot B$

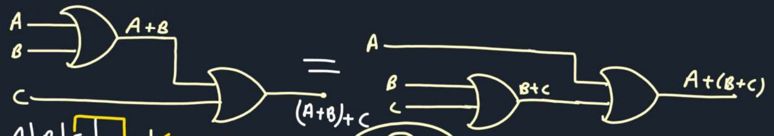
A	B	A·B
0	0	0
0	1	0
1	0	0
1	1	1

B	A	B·A
0	0	0
0	1	0
1	0	0
1	1	1

$[A \cdot B \cdot C \cdot D = B \cdot C \cdot D \cdot A]$

Associative Law:⇒

Law:-1) $(A+B)+C = A+(B+C)$



	A	B	C	A+B	(A+B)+C
0 –	0	0	0	0	0
1 –	0	0	1	0	1
2 –	0	1	0	1	1
3 –	0	1	1	1	1
4 –	1	0	0	1	1
5 –	1	0	1	1	1
6 –	1	1	0	1	1
7 –	1	1	1	1	1

A	B	C	B+C	A+(B+C)
0	0	0	0	0
0	0	1	1	1
0	1	0	1	1
0	1	1	1	1
1	0	0	0	1
1	0	1	1	1
1	1	0	1	1
1	1	1	1	1

Law:-2>

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

Distributive Law

Law:-1> $A\cdot(B\pm C) = A\cdot B \pm A\cdot C$

Law:-2> $A+(B.C) = (A+B).(A+C)$

V.V.g → Redundant Literal Rule (RLR)

Law:-1> $A+\bar{A}B = A+B$ $[x+\bar{x}y = x+y]$

Prove:- $(A+\bar{A})\cdot(A+B)$

$1\cdot(A+B) = A+B$

Law:-2> $A\cdot(\bar{A}+B) = A\cdot B$ ✓

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

$0 + A\cdot B = A\cdot B$

→ Involution Law:-

$\bar{\bar{A}} = A$ $[\bar{\bar{x}} = x]$ $\overline{\overline{A\cdot B}} = A\cdot B$

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

→ Idempotence Law:-

Law:-1> $A+A+A+\ldots = A$

Law:-2> $A\cdot A\cdot A\ldots = A$

Absorption Law:⇒

Law:-1> $A+A\cdot B = A$

$A+AB+ABC+ABCD = A$

Prove:- $A+A\cdot B$

$A\cdot(1+B)$

$A\cdot 1 = A$ ✓

$A\cdot(A+B) = A$ ✓

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

$A + A\cdot B$

$A(1+B)$

$A\cdot 1 = A$

DE-MORGAN'S THEOREM

This theorem is used to Convert Sum of Product (SOP) Expression into Product of Sum (POS) & Vice Versa.

Note:- $f(A,B,C)$

$Y = \underbrace{A\cdot B\cdot C}_{\text{Product term}} + \underbrace{A\cdot C}_{\text{Product term}} + \underbrace{B\cdot C}_{\text{Product term}} + \underbrace{A\cdot\overline{B}\cdot C}_{\text{Product Term}} \rightarrow$ Sum of Product (SOP)

↕

$Y = \underbrace{(A+B+C)}_{\text{Sum term}}\cdot\underbrace{(B+C)}_{\text{Sum term}}\cdot\underbrace{(\overline{A}+B+C)}_{\text{Sum t}} \rightarrow$ Product of Sum (POS)

There are two Basic De Morgan's Theorem:⇒

Theorem:-1 De Morgan's first theorem explain that

Complement of Sum is equal to Product of Complement.

$\underbrace{\overline{A+B+C+D}}_{\text{Complement of Sum}} = \overline{A}\cdot\overline{B}\cdot\overline{C}\cdot\overline{D}$

= Product of Complement

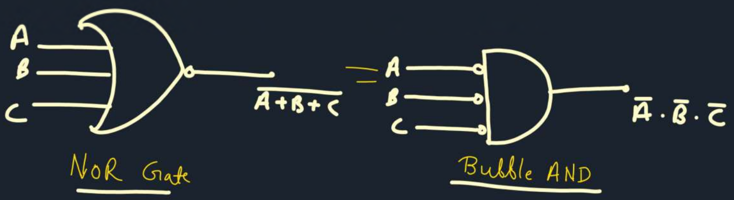
[Trick:- Breaking the line & Changing the Sign $(\cdot \leftrightarrow +)$

or

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

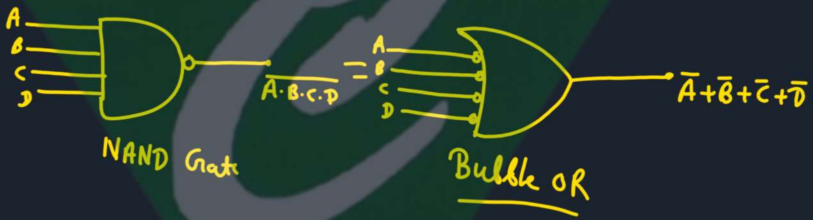
$\overline{A+B+C} = \overline{A}\cdot\overline{B}\cdot\overline{C}$

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



Theorem:-2 ⟩ De Morgan's 2nd theorem States that Complement of Product is equal to the Sum of Complement.

$$\overline{A\cdot B\cdot C\cdot D} = \bar{A}+\bar{B}+\bar{C}+\bar{D}$$



Q Using Basic laws & Theorems Simplify the following Expression.

De Morgan's
Breaking the line & Changing the Sign

① Q:- $Z = \overline{\overline{x+y} + \overline{x\cdot y} + \bar{x}y}$

$\because \bar{\bar{A}} = A$

Sol^n:→ $Z = (\overline{\overline{x+y}})\cdot(\overline{\overline{x\cdot y}})\cdot(\overline{\bar{x}\cdot y})$

$Z = (x+y)\cdot(x\cdot y)(\bar{\bar{x}}+\bar{y})$

$(A\cdot A = A)$
$(A+A=A)$
$(A\cdot\bar{A}=0)$

$(ABC + ABC = ABC)$
$A+A+A+\ldots = A$

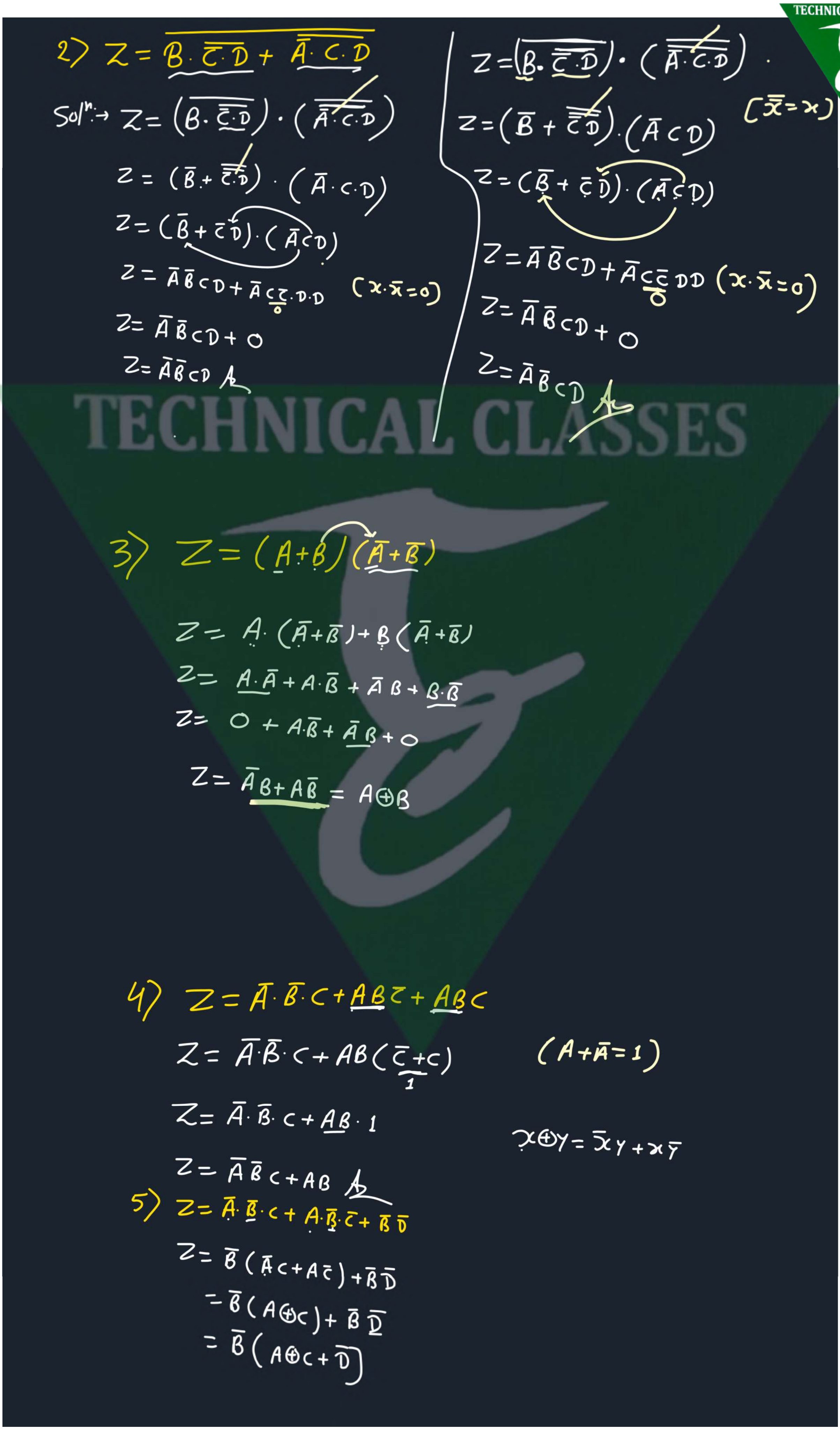
$Z = (xxy + xyy)(x+\bar{y})$

$Z = (xy+xy)(x+\bar{y})$

$Z = xy(x+\bar{y})$

$Z = xxy + xy\bar{y} = xy + 0 = xy$

$\boxed{Z = xy}$



2) $Z=\overline{B\cdot\overline{\bar{C}\cdot D}+\overline{\bar{A}\cdot C\cdot D}}$

Sol^n:→ $Z=\left(\overline{B\cdot\overline{\bar{C}\cdot D}}\right)\cdot\left(\cancel{\overline{\overline{\bar{A}\cdot C\cdot D}}}\right)$

$Z=(\bar{B}+\cancel{\overline{\overline{\bar{C}\cdot D}}})\cdot(\bar{A}\cdot C\cdot D)$

$Z=(\bar{B}+\bar{C}D)\cdot(\bar{A}CD)$

$Z=\bar{A}\bar{B}CD+\bar{A}\underbrace{C\bar{C}}_{0}\cdot D\cdot D$ $(x\cdot\bar{x}=0)$

$Z=\bar{A}\bar{B}CD+0$

$Z=\bar{A}\bar{B}CD$ A

$Z=\left(\overline{B\cdot\overline{\bar{C}\cdot D}}\right)\cdot\left(\cancel{\overline{\overline{\bar{A}\cdot C\cdot D}}}\right)$.

$[\bar{\bar{x}}=x]$

$Z=(\bar{B}+\cancel{\overline{\overline{\bar{C}D}}})\cdot(\bar{A}CD)$

$Z=(\bar{B}+\bar{C}D)\cdot(\bar{A}CD)$

$Z=\bar{A}\bar{B}CD+\bar{A}\underbrace{C\bar{C}}_{0}DD$ $(x\cdot\bar{x}=0)$

$Z=\bar{A}\bar{B}CD+0$

$Z=\bar{A}\bar{B}CD$ A

3) $Z=(A+B)(\bar{A}+\bar{B})$

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

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

$Z=0+A\bar{B}+\bar{A}B+0$

$Z=\bar{A}B+A\bar{B}=A\oplus B$

4) $Z=\bar{A}\cdot\bar{B}\cdot C+AB\bar{C}+ABC$

$Z=\bar{A}\cdot\bar{B}\cdot C+AB(\underbrace{\bar{C}+C}_{1})$

$(A+\bar{A}=1)$

$Z=\bar{A}\cdot\bar{B}\cdot C+AB\cdot 1$

$x\oplus y=\bar{x}y+x\bar{y}$

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

5) $Z=\bar{A}\cdot\bar{B}\cdot C+A\cdot\bar{B}\cdot\bar{C}+\bar{B}\bar{D}$

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

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

$=\bar{B}(A\oplus C+\bar{D}]$

NAND Gate & NOR Gate

Both are Universal Gate.

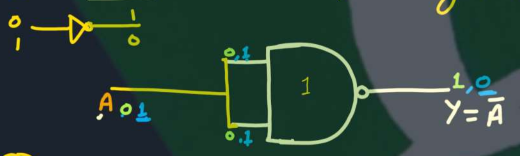
Because all Gates can be realized by Using only NAND Gate or NoR Gate

APPlication of NAND Gate

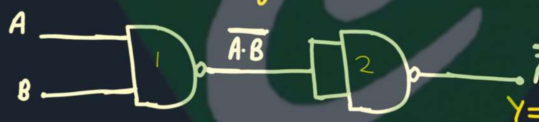
A	B	$Y = \overline{A\cdot B}$
0	0	1
0	1	1
1	0	1
1	1	0

$\bar{\bar{A}} = A$

① NOT Gate by Using NAND ①



② AND Gate by Using NAND ②

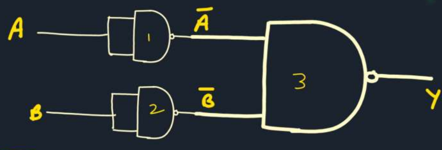


$\overline{\overline{A\cdot B}} = A\cdot B$

$Y = A\cdot B$

③ OR Gate by Using NAND ③

Bubble NAND = OR Gate



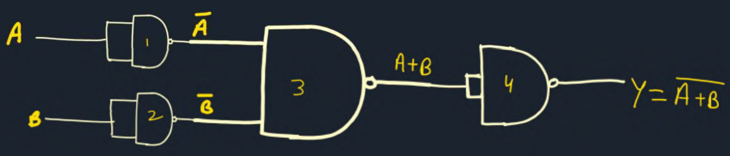
$Y = \overline{\bar{A}\cdot\bar{B}} = \bar{\bar{A}} + \bar{\bar{B}}$

$\boxed{Y = A+B}$

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

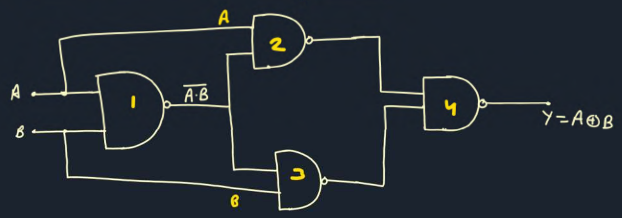
$= A+B$

④ NOR Gate by Using NAND ④

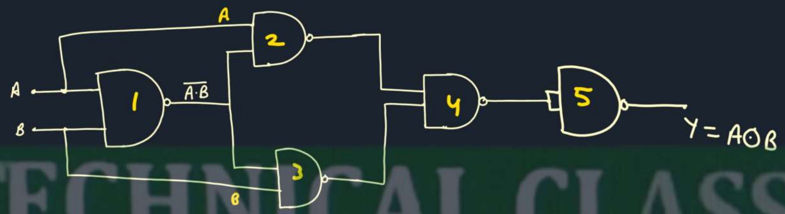


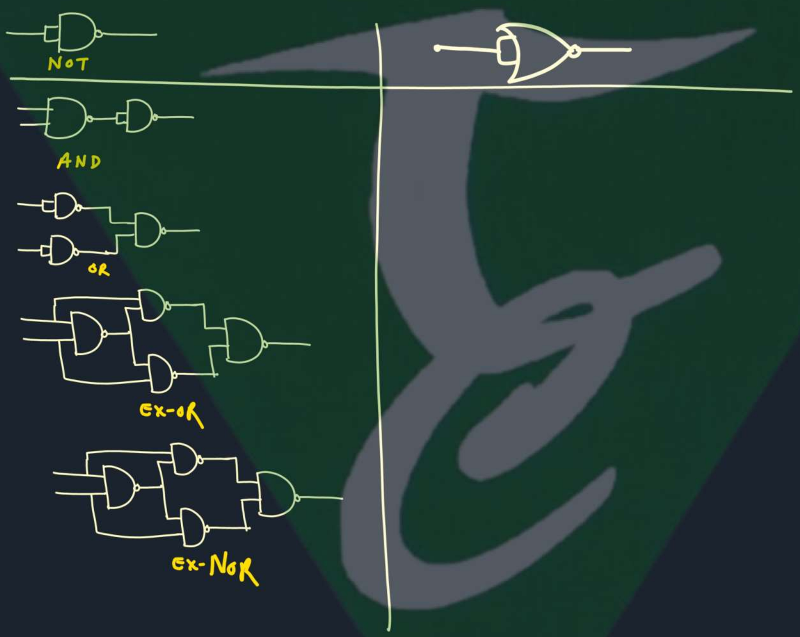
④

5> EX-OR Gate by Using NAND



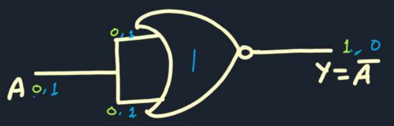
6> EX-NOR Gate by Using NAND



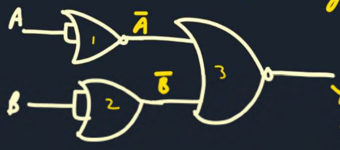


Application of NOR Gate

① NOT Gate by Using NOR



2> AND Gate by Using NOR



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

$Y = A\cdot B$

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

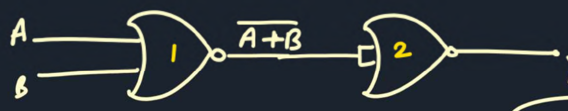
Bubble NOR = AND

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

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

$\boxed{Y = A\cdot B}$

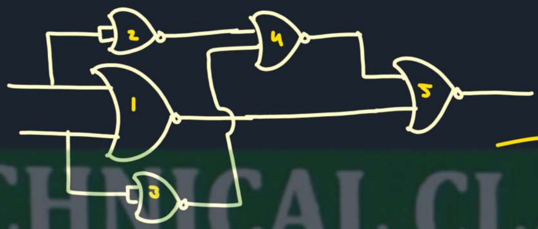
3) OR Gate by Using NOR



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

$\boxed{Y = A+B}$ OR

4) EX-OR Gate



$A \oplus B$

Logic Gate	No. of NAND	No. of NOR
Not	1	1
AND	2	3
OR	3	2
Ex-OR	4	5
Ex-NOR	5	4

V.V.g M.C.Q

Boolean function

The function of binary Varriables is Known as Boolean function or Boolean expression.

A → 0 ($\overline{A}$) → Complement Value
A → 1 (A) → Normal Value (Logic 1)

There are two ways to express Boolean functions :→

1) Sum of Product (SOP)
2) Product of Sum (POS)

Sum of Product (SOP)

The Boolean expression in which Product terms are Sum together is Known as SOP expression.

$$f(A,B,C) = \underbrace{A\cdot\overline{B}\cdot C}_{P.T} + \underbrace{A\cdot B}_{PT} + \underbrace{A\cdot\overline{C}}_{PT} + \underbrace{\overline{B}\cdot C}_{PT}$$

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

Product of Sum (Pos)

The Boolean Expression in which Sum terms are multiplied together is Known as Product of Sum.

$$f(A,B,C) = (\underbrace{A+\overline{B}+C}_{ST})\cdot(\underbrace{A+B}_{ST})\cdot(\underbrace{B+C}_{ST})$$

$$f(A,B,C) = (\underbrace{A+B}_{ST})\cdot(\underbrace{\overline{A}+B+C}_{ST})\cdot(\underbrace{A+\overline{B}+C}_{ST})$$

$A\cdot B + A\cdot\overline{B}C + \overline{A}BC \rightarrow$ SoP

$\overline{A}\cdot B + A\cdot B\cdot C + B\overline{C} \rightarrow$ SoP

$(A+B+C)\,(A+\overline{B}+C)\,(\overline{A}+C) \rightarrow$ Pos

Canonical

Standard Product [Min term]

Standard Product or Min terms are those Which Consists of all the binary Varriables either in normal form or Complement form. The Value of min terms is logic '1.'

It is denoted by m_i. Here i represents decimal equivalent Value.

If we have 3 binary Varriable (A, B, C) Then Possible min terms are $2^3 = 8$

i.e. f(A, B, C)

Decimal No.	Binary Varriables A	B	C	Min terms (m_i)
0	0	0	0	$m_0 = \bar{A}\cdot\bar{B}\cdot\bar{C}$
1	0	0	1	$m_1 = \bar{A}\,\bar{B}\,C$
2	0	1	0	$m_2 = \bar{A}\,B\,\bar{C}$
3	0	1	1	$m_3 = \bar{A}\,B\,C$
4	1	0	0	$m_4 = A\,\bar{B}\,\bar{C}$
5	1	0	1	$m_5 = A\,\bar{B}\,C$
6	1	1	0	$m_6 = A\,B\,\bar{C}$
7	1	1	1	$m_7 = A\,B\,C$

Canonical

Standard SUM or Max term [M_i]

Standard Sum or Max terms are those that Contains all Varriables either in normal form or in Complement form.

The Value of Max term is logic 0

$0 \rightarrow A$ → Normal

$1 \rightarrow \bar{A}$ → Complement

Here Max term is represented as M_i

If f(A, B, C) we have 3 Varriables:-

Decimal No.	Binary Variables			Max term
	A	B	C	(M_i)
0	0	0	0	$M_0 = A+B+C$
1	0	0	1	$M_1 = A+B+\bar{C}$
2	0	1	0	$M_2 = A+\bar{B}+C$
3	0	1	1	$M_3 = A+\bar{B}+\bar{C}$
4	1	0	0	$M_4 = \bar{A}+B+C$
5	1	0	1	$M_5 = \bar{A}+B+\bar{C}$
6	1	1	0	$M_6 = \bar{A}+\bar{B}+C$
7	1	1	1	$M_7 = \bar{A}+\bar{B}+\bar{C}$

Conversion from SOP to Canonical SOP

$[x+\bar{x}=1]$

① $f(A,B,C) = \underline{A} + \underline{B\cdot C}$

$$= A\cdot\overset{1}{(B+\bar{B})}\cdot\overset{1}{(C+\bar{C})} + (A+\bar{A})\cdot BC$$

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

$$= \underset{111}{ABC} + \underset{101}{A\bar{B}C} + \underset{110}{AB\cdot\bar{C}} + \underset{100}{A\bar{B}\bar{C}} + \underset{111}{ABC} + \underset{011}{\bar{A}BC}$$

$$= m_7 + m_5 + m_6 + m_4 + m_7 + m_3$$

$$= m_3 + m_4 + m_5 + m_6 + m_7$$

$$= \sum m(3,4,5,6,7)$$

2) $f(A,B,C) = \underset{C}{AB} + \bar{A}BC$

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

$$= \underset{\underset{m_7}{111}}{ABC} + \underset{\underset{m_6}{110}}{AB\bar{C}} + \underset{\underset{m_3}{011}}{\bar{A}BC}$$

$$= m_3 + m_6 + m_7$$

$$= \sum m(3,6,7)$$

Karnaugh's Map (K-Map)

The Simplification of Boolean expression Using boolean algebra is an Unconditional Process. It doesn't follow any Specific sequence. To over come this Problem an alternative method is used. This alternative method is known as K-Map.

Format of K-Map :-

A K-Map Consists of a number of Squares. for n-Variables, Total number of squares in map is 2^n.

for example:-

2- Varriables (A,B)

No. of Squares = $2^2 = 4$

A \ B	$\bar{B}$ 0	B 1
($\bar{A}$) 0	$\bar{A}\bar{B}$ m_0	$\bar{A}B$ m_1
A 1	$A\bar{B}$ m_2	AB m_3

for 3 Variables (A, B, C)

No. of Squares = $2^3 = 8$.

A \ BC	$\bar{B}\bar{C}$ 00	$\bar{B}C$ 01	BC 11	$B\bar{C}$ 10
($\bar{A}$) 0	$\bar{A}\bar{B}\bar{C}$ m_0	$\bar{A}\bar{B}C$ m_1	$\bar{A}BC$ m_3	$\bar{A}B\bar{C}$ m_2
(A) 1	$A\bar{B}\bar{C}$ m_4	$A\bar{B}C$ m_5	ABC m_7	$AB\bar{C}$ m_6

3-Variables f(A, B, C)

B C
0 0
0 1
1 0
1 1

A \ BC	$\bar{B}\bar{C}$ 00	$\bar{B}C$ 01	BC 11	$B\bar{C}$ 10
0 $\bar{A}$	000 $\bar{A}\bar{B}\bar{C}$ m_0	001 $\bar{A}\bar{B}C$ m_1	011 $\bar{A}BC$ m_3	010 $\bar{A}B\bar{C}$ m_2
A 1	100 $A\bar{B}\bar{C}$ m_4	101 $A\bar{B}C$ m_5	111 ABC m_7	110 $AB\bar{C}$ m_6

Karnaugh's Map (K-Map)

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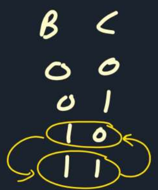
A 1	$A\bar{B}$ m_2	AB m_3

for 3 Variables (A, B, C)

No. of Squares $= 2^3 = 8$.

A \ BC	$\bar{B}\bar{C}$ 00	$\bar{B}C$ 01	BC 11	$B\bar{C}$ 10
($\bar{A}$) 0	$\bar{A}\bar{B}\bar{C}$ m_0	$\bar{A}\bar{B}C$ m_1	$\bar{A}BC$ m_3	$\bar{A}B\bar{C}$ m_2
(A) 1	$A\bar{B}\bar{C}$ m_4	$A\bar{B}C$ m_5	ABC m_7	$AB\bar{C}$ m_6

3-Variables $f(A, B, C)$



A \ BC	$\bar{B}\bar{C}$ 00	$\bar{B}C$ 01	BC 11	$B\bar{C}$ 10
$\bar{A}$ 0	000 $\bar{A}\bar{B}\bar{C}$ m_0	001 $\bar{A}\bar{B}C$ m_1	011 $\bar{A}BC$ m_3	010 $\bar{A}B\bar{C}$ m_2
A 1	100 $A\bar{B}\bar{C}$ m_4	101 $A\bar{B}C$ m_5	111 ABC m_7	110 $AB\bar{C}$ m_6

4- Variables f(A, B, C, D)

No. of square = $2^4 = 16$

AB \ CD	$\bar C\bar D$ 00	$\bar C D$ 01	CD 11	$C\bar D$ 10
00 $\bar A\bar B$	0000 $\bar A\bar B\bar C\bar D$ m_0	0001 $\bar A\bar B\bar C D$ m_1	0011 $\bar A\bar B CD$ m_3	0010 $\bar A\bar B C\bar D$ m_2
01 $\bar A B$	0100 $\bar A B\bar C\bar D$ m_4	0101 $\bar A B\bar C D$ m_5	0111 $\bar A BCD$ m_7	0110 $\bar A BC\bar D$ m_6
11 AB	1100 $AB\bar C\bar D$ m_{12}	1101 $AB\bar C D$ m_{13}	1111 $ABCD$ m_{15}	1110 $ABC\bar D$ m_{14}
10 $A\bar B$	1000 $A\bar B\bar C\bar D$ m_8	1001 $A\bar B\bar C D$ m_9	1011 $A\bar B CD$ m_{11}	1010 $A\bar B C\bar D$ m_{10}

How to enter in K-map

→ Bring the given expression in Canonical SoP or Pos in terms of minterms or maxterm respectively.

In Case of Canonical SoP expression, for each minterm is Substituted by 1.

In Case of Canonical Pos expression for each maxterm is Substituted by 0.

* Draw K-map for given expression

Q:- $f(A,B,C) = \bar A B + \bar B C + A\bar C$

A \ BC				
	m_0	m_1	m_3	m_2
	m_4	m_5	m_7	m_6

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

$$\underset{011}{\bar A BC} + \underset{010}{\bar A B\bar C} + \underset{101}{A\bar B C} + \underset{001}{\bar A\bar B C} + \underset{110}{AB\bar C} + \underset{100}{A\bar B\bar C}$$

m_3 m_2 m_5 m_1 m_6 m_4

$\Sigma m(1, 2, 3, 4, 5, 6)$

A \ BC	00 $\bar B\bar C$	01 $\bar B C$	11 BC	10 $B\bar C$
0 $\bar A$	m_0	1 m_1	1 m_3	1 m_2
1 A	1 m_4	1 m_5	m_7	1 m_6

2) $f(A,B,C) = \sum m(0, 2, 3, 5, 7)$

A \ BC	00 $\bar{B}\bar{C}$	01 $\bar{B}C$	11 BC	10 $B\bar{C}$
0 $\bar{A}$	1 m_0	m_1	1 m_3 ↔	1 m_2
1 A	m_4	1 m_5	1 m_7	m_6

Procedure for grouping:- $[1, 2, 4, 8, 16, 32]$

$2^0, 2^1, 2^2, \ldots$

① Only adjacent square can be grouped.

② The number of 1's or 0's in group must be 1, 2, 4, 8 .... so on.

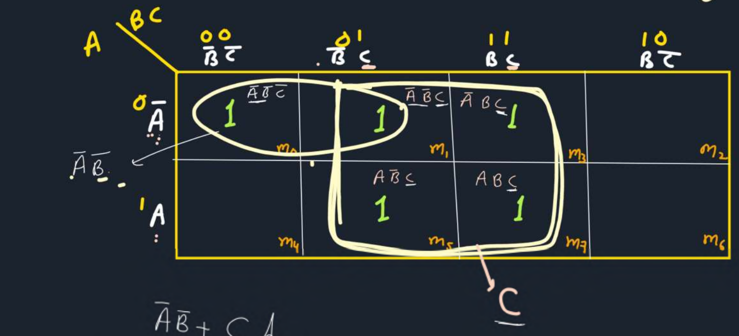
→ Pair:- The group of two 1's or 0's

→ Quad:- The group of four 1's or 0's

→ Octat:- The group of eight 1's or 0's

①Q:- Simplify the given expression:-

1) $f(A,B,C) = \sum m(0, 1, 3, 5, 7) = \bar{A}\bar{B} + C$



A \ BC	00 $\bar{B}\bar{C}$	01 $\bar{B}C$	11 BC	10 $B\bar{C}$
0 $\bar{A}$	$\bar{A}\bar{B}\bar{C}$ 1 m_0	$\bar{A}\bar{B}C$ 1 m_1	$\bar{A}BC$ 1 m_3	m_2
1 A	m_4	$A\bar{B}C$ 1 m_5	ABC 1 m_7	m_6

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