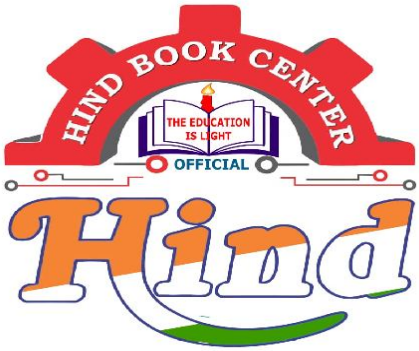


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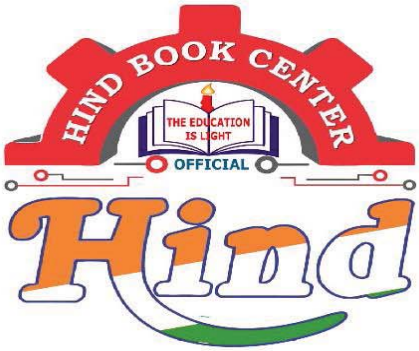
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NETWORK THEORY

-Aditya sir

ESE: 22-24 M
≈ 14 que.
Gate: 10M

◉ Topics:

① Basics:
- Φ, I, V, P, N
- R, L, C
- KVL, KCL, ohm's Law
- Mesh Nodal
- Equivalent R, L, C, Z

② Two-port Network:
- Parameters (Z, y, h, g, T, t)
- Interconnection
- Gyrator

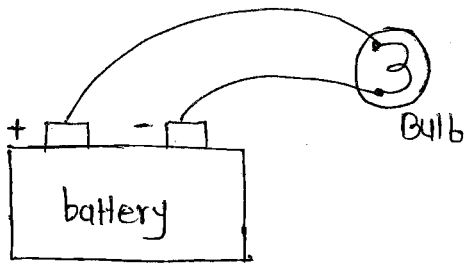
③ Theorems:
- superposition
- Thevenin
- Nortons
- Maximum power Transfer

(Thevenin, Nortons, Maximum power Transfer: Gate)

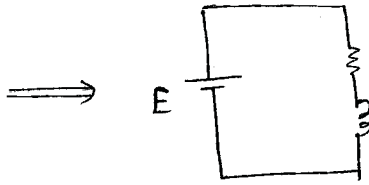
- Reciprocity
- Millman's
- Compensation
- substitution
- Tellegen's theorem

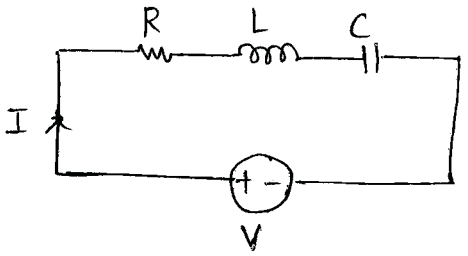
(All: ESE)

④ Transient:
- 1st order circuit (RC, RL)
- 2nd order circuits
- Initial condition
- Laplace transform

⊙ 

Electrical circuit : our main Aim is to transferred the energy from one Point to another Point. Hence for this We required An interconnection betⁿ electrical compo.



⊙ 

Interview

Highest basic quantity in electrical Network : Charge

● Charge : - charge is the electrical property of the atomic partical of which the Matter Consist of. (C)

- [Electrical Property → Atomic Particles → Matter]

Charge on $\boxed{1e^- : -1.6 \times 10^{-19} C}$ Coulomb is the large Unit of charge.

Que: How many electron contributes towards 1C of charge?

Solⁿ : $1e^- = 1.6 \times 10^{-19} C$

$$1C = \frac{1}{1.6 \times 10^{-19}} e^- s$$

$$\boxed{1C = 6.24 \times 10^{18} e^- s}$$

⊙ Law of conservation of charge :

It states that, charge can be neither be created nor be destroyed. It can be only transferred from one body to another body.

Any eqⁿ with the help of show Law of conse. of Charge.

Continuity Eqⁿ : $\nabla . \bar{J} = -\frac{d\rho_v}{dt}$

Lec-2

② **Current :** The flow of the electrons or the time rate of change of charge through any cross-section is called as a current. (C/s or Amp)

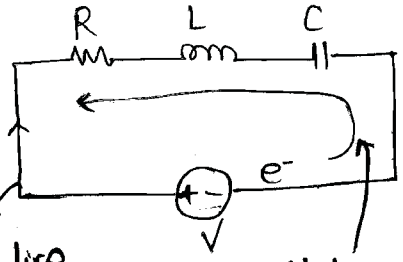
$$\boxed{I_{av} = \frac{\Delta q}{\Delta t}} \quad C/s \text{ or } AMP.$$

- Instantaneous current i(t):

$$i(t) = \lim_{\Delta t \to 0} \frac{\Delta q}{\Delta t} = \frac{dq}{dt}$$

$$\boxed{i(t) = \frac{dq}{dt}}$$

- Direction of current in electrical circuit :



Metal Wire
(Holes does not exist in a metal)

Natural current dirn

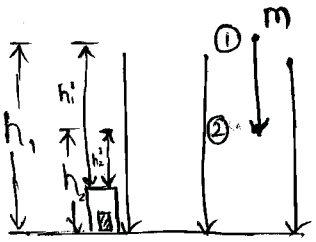
Conventionally, ---→ the current direction is taken in the direction of the positive charge moment.

Naturally, ---→ the current direction is in the direction of the flow of electrons.

③ **Voltage :** ① To move the electron from one point to Another Point in a particular direction & external force is required & in an electrical circuit this force is provided by the electromotive force (EMF) & it is given by

$$\boxed{E = V = \frac{dW}{dt}} \quad J/C \text{ or } V$$

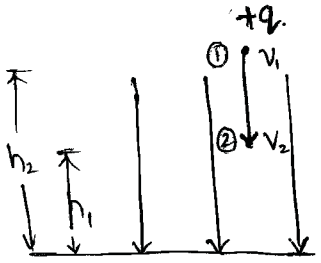
② Voltage or potential difference is the energy required to move a unit charge through an element.



Energy gained by the mass in moving from pt. ① to ② :

$= mg(h_1 - h_2)$

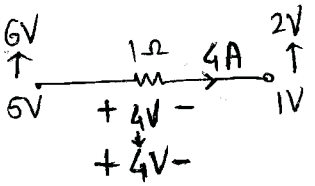
gravitational potential diff.



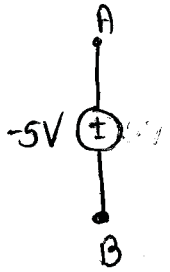
Energy gained by the charge in moving from pt ① to ② :

$= q(V_1 - V_2)$

Electrical potential difference.



Que:



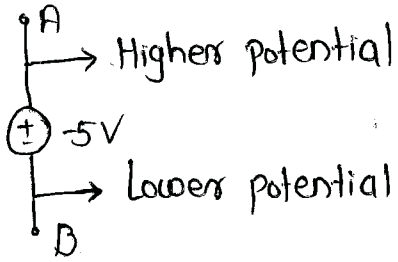
ⓐ $V_A > V_B$

ⓑ $V_A = V_B$

ⓒ $V_A < V_B$

ⓓ Cant Comment

Soln:



Higher Pot. − Lower Pot. $= -5V$

$V_A - V_B = -5V$

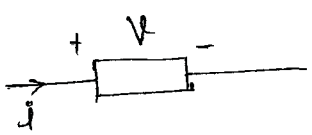
$V_A = V_B - 5$

④ Power: It is the time rate of change of Energy [expending or absorbing] and (Watts)

$$\boxed{P = \frac{dW}{dt}} \quad J/s \text{ or } W$$

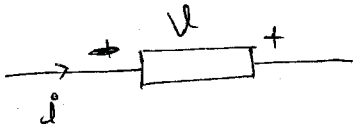
$$P = \frac{dW}{dq} \cdot \frac{dq}{dt}$$

$$\boxed{P(t) = V(t) \cdot I(t)}$$



$P = +Vi$

(a)



$P = -Vi$

(b)

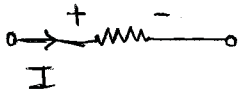
- Whenever we calculate the power by using the formula $V \times I$, We always get the power absorbed.

Fig. (a) Power absorbed or Power received or power dissipated

Fig. (b) Power absorbed is -ve. or Power is getting delivered ($P_{del} = +Vi$)

Note: ① Whenever current entere into the +ve terminal of the voltage polarity, the element absorbs a power

② And when the current leaves from the +ve terminal or current enter into the -ve terminal, then the element delivers the power.

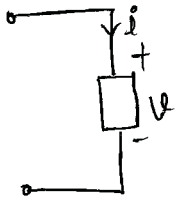


Power absorbed

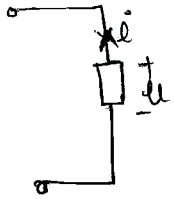


Power delivered

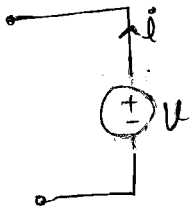
- Hence, for determine Sign of the power, The voltage Polarity & the c/n direction are important.



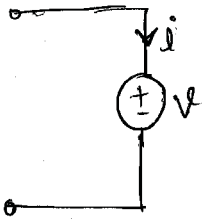
Power abso.
∴ Load



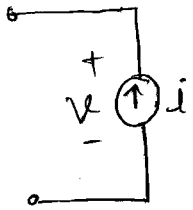
Power deli.
∴ Source



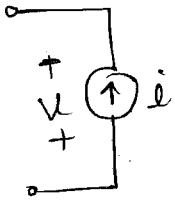
Power deli.
∴ Source



Power abs.
∴ Sink / Load



Power del.
∴ Source



Power abs.
∴ Load

⊙ Law of Conservation of Energy :

It states that, Energy can neither be created nor be destroyed, It only be transform from one form to another Form.

∴ In Any Electrical Circuit :

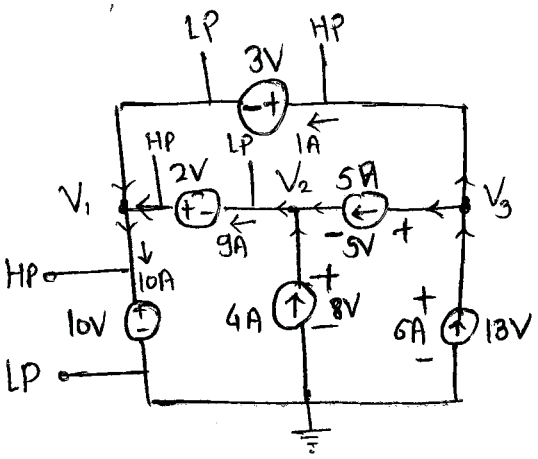
$$\Sigma P = 0$$

$$\Sigma P_{del.} = \Sigma P_{abs.}$$

- The algebric sum of the power at any instant of time in a circuit must be equal to zero.

Lec-3

Que. Find the power of each element In the below given electrical Network.



Soln:

$P_{10V} = +10 \times 10$
$= +100\ W$

$P_{2V} = -9 \times 2$
$= -18\ W$

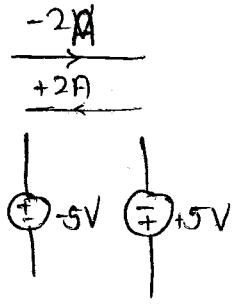
$P_{3V} = +3 \times 1$
$= 3W$

- By Nodal Analysis:

$V_1 - 0 = 10V$
$V_1 = 10V$

$V_1 - V_2 = 2V$
$-V_2 = 2 - 10$
$V_2 = 8V$

$V_3 - V_1 = 3V$
$V_3 = 13V$



$P_{4A} = -4 \times 8$
$= -32\ W$

$P_{5A} = +5 \times 5V$
$= 25\ W$

$P_{6A} = -13 \times 6$
$= -78\ W$

- Not part of Soln:

$\Sigma P_{abs.} = +100 + 3 + 25$ --- (+Ve Power)
$= 128\ W$

$\Sigma P_{del.} = +8 + 32 + 78$ --- (-Ve power with +ve sign)
$= 128\ W$

$\therefore \Sigma P_{del.} = \Sigma P_{abs.}$

Que: How many electrons flow per second through the fillament offer 220V & 110W electric bulb.

Soln: $P = V \times I$ $\quad I = \frac{P}{V} = \frac{110}{220} = \frac{1}{2}$ Amp

$I = \frac{Q}{t} = \frac{n.e^-}{t}$ where, n = Total no. of e^-

$\frac{n}{t} = 3.125 \times 10^{-8}$ --- $\left[\because \frac{n}{t} = \frac{I}{e^-} = \frac{1/2}{1.6 \times 16^{-19}}\right]$

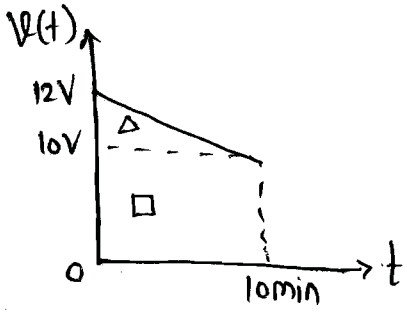
⑤ Energy : It is the capacity or ability to do the work. (J or Watt-sec)

$$W(t) = \int_0^t P(t).dt.$$

$$\boxed{W(t) = \int_0^t V(t).i(t).dt}$$

Que. A fully charged mobile phone with a 12V battery is good for 10 min talktime; Assume that during the talktime, battery delivers a constant C/n of 2A and its voltage linearly drop From 12V to 10V as shown in the fig. How much energy dees the battery delivered during talktime.

Gate 2009



Sol^n: $W = \int_0^t P(t).dt$

$= \int_0^t V(t).i(t).dt$

$= 2\left[\int_0^{10\,min} V(t).dt\right]$

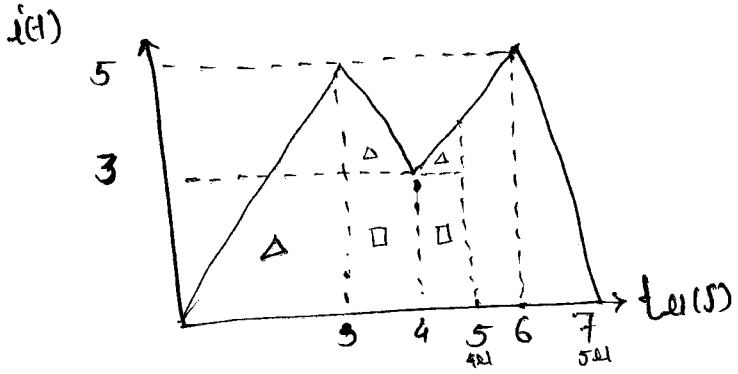
$= 2\left[\left(\frac{1}{2} \times 10min \times (12-10)\right) + (10 \times 10)\right].60$

$= 2\,[10 + 100]\,60$

$= 2 \times 6600$

$$\boxed{W = 13.2\ KJ}$$

que. A c/n $i(t)$ as shown in the fig. is passed thr a capacitor. A charge in uc aquire by the cap^r in 5us. will be....



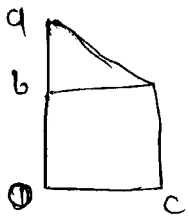
Soln: $i(t) = \frac{dq}{dt}$

$$q = \int_{-\infty}^{t} i(t).dt.$$

$$q(t) = \int_{-\infty}^{0} i(t).dt + \int_{0}^{t} i(t).dt.$$

$$\boxed{q(t) = q(0) + \int_{0}^{t} i(t).dt} \quad \star$$

$$q(t) = 0 + \int_{0}^{5\,u} i(t).dt$$



Area: $\frac{1}{2}(a-b)c + bc$

$= \frac{1}{2}ac - \frac{1}{2}bc + bc$

$= \frac{1}{2}ac + \frac{1}{2}bc$

$$\boxed{\text{Area} = \frac{1}{2}(a+b)c} \quad \star$$

$$\therefore \text{Area} = \int_{0}^{3\,u} i(t).dt + \int_{3\,u}^{4\,u} i(t).dt + \int_{4\,u}^{5\,u} i(t).d(t)$$

$$= \left[\frac{1}{2}\times 5\times 3\right] + \left[\frac{1}{2}(5+3).1\right] + \left[\frac{1}{2}(4+3).1\right]$$

$$= \left[\frac{15}{2} + \frac{8}{2} + \frac{7}{2}\right] u$$

$$q(t) = \frac{30}{2}\,u$$

$$\boxed{q = 15\,uC}$$

que: Cln flowing through the ckt element is given by.
$i(t) = (8t+5)A$. find amount of charge passing thr the element in an interval of 0 to 3 sec.

Soln: Given;

$i(t) = (8t+5)\,A$

$$\boxed{q(t) = 0 + \int_0^t i(t)\,dt}$$

$$q(t) = 0 + \int_0^3 (8t+5)\,dt$$

$$= 8 \cdot \frac{t^2}{2}\Big]_0^3 + 5 \cdot t\Big]_0^3$$

$$= 4(3)^2 + 5(3)$$

$$= 36 + 15$$

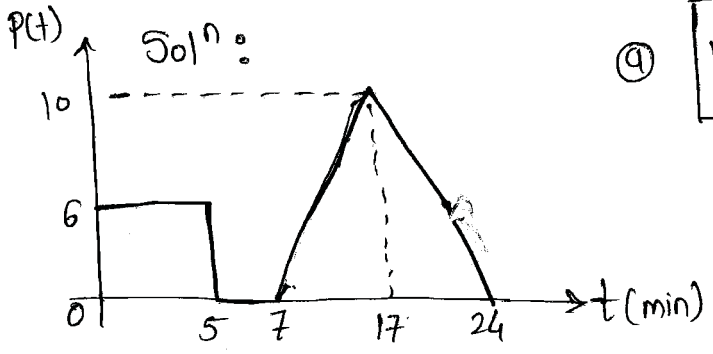
$$\boxed{q(t) = 51C}$$

Que: The power supplied by a certain battery is constant. 6 W for the 1st 5 min. then. 0 for the following 2 min. the value that increases from 0 to 10W for the next 10 min. and a power that decreases linearly from 10W to 0 in the following 7 min.

(a) What is the total energy in J. expended during this 24 min. interval. ~~second~~.

(b) What is the avg. power in Watt during this time.

Soln:



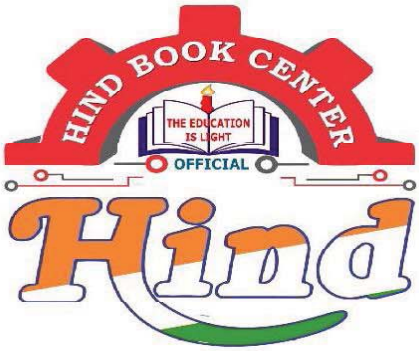
(a) $$\boxed{W = \int_0^t p(t)\,d(t)}$$

$$= [6 \times 5] + \left[\tfrac{1}{2} \times 10 \times 10\right] + \left[\tfrac{1}{2} \times 10 \times 7\right]$$

$$= [30 + 50 + 35] \times 60$$

$$= (115 \times 60)$$

$$W = 6900\,J$$



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-: Vector Analysis :-

I). co-ordinate system :-

There are 3-types of co-ordinate systems

ⓐ Cartesian co-ordinate system (x, y, z)

ⓑ Cylindrical co-ordinate system (s, φ, z)

ⓒ spherical co-ordinate system (r, θ, φ)

All these co-ordinate systems obeys two laws-

ⓐ Rule of orthogonality :-

(i) The dot product of two similare vectors of the same co-ordinate system results 1.

Ex:- $\hat{a}_x \cdot \hat{a}_x = 1$; ca-co-system

$\hat{a}_s \cdot \hat{a}_s = 1$; cy-co-system

$\hat{a}_r \cdot \hat{a}_r = 1$; sp-co-system

(ii) The dot product of two different of unit vectors of the same co-ordinate system results to 0.

Ex-: $\hat{a}_x \cdot \hat{a}_y = 0$; ca·co·syst.

$\hat{a}_s \cdot \hat{a}_\varphi = 0$; cy·co·syst.

$\hat{a}_r \cdot \hat{a}_\theta = 0$; sp·co·syst.

ⓑ Rule of orthonormality :-

(i) The cross product of two similar unit vectors of same co-ordinates system results to '0'.

Ex-: $\hat{a}_x \times \hat{a}_x = 0$; ca·co·syst.

$\hat{a}_\varphi \times \hat{a}_\varphi = 0$; cy co syst.

$\hat{a}_r \times \hat{a}_r = 0$; sp·co·syst.

(ii) The cross product of two different unit vectors of same co-ordinates system results to third unit vector which is mutually perpendicular to the initial vectors

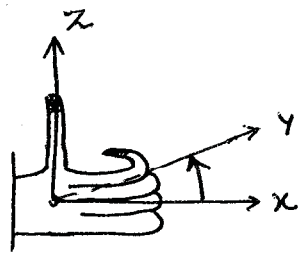
Ex:- $\hat{a_x} \times \hat{a_y} = \hat{a_z}$; ca·co·syst.

$\hat{a_\rho} \times \hat{a_\varphi} = \hat{a_z}$; cy·co·syst.

$\hat{a_r} \times \hat{a_\theta} = \hat{a_\varphi}$; sp·co·syst.

(iii) the direction of 3rd unit vector is found using R-H curl rule.

Ex:-

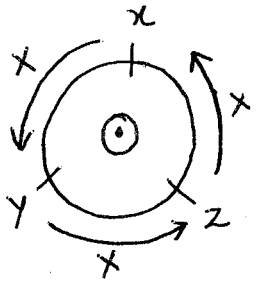


R-H curl Thumb

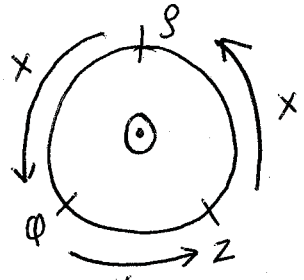
x y z

⊙ ≡ out of plane

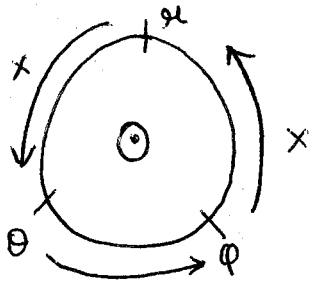
⊗ ≡ into the plane



-: ca·co·system :-

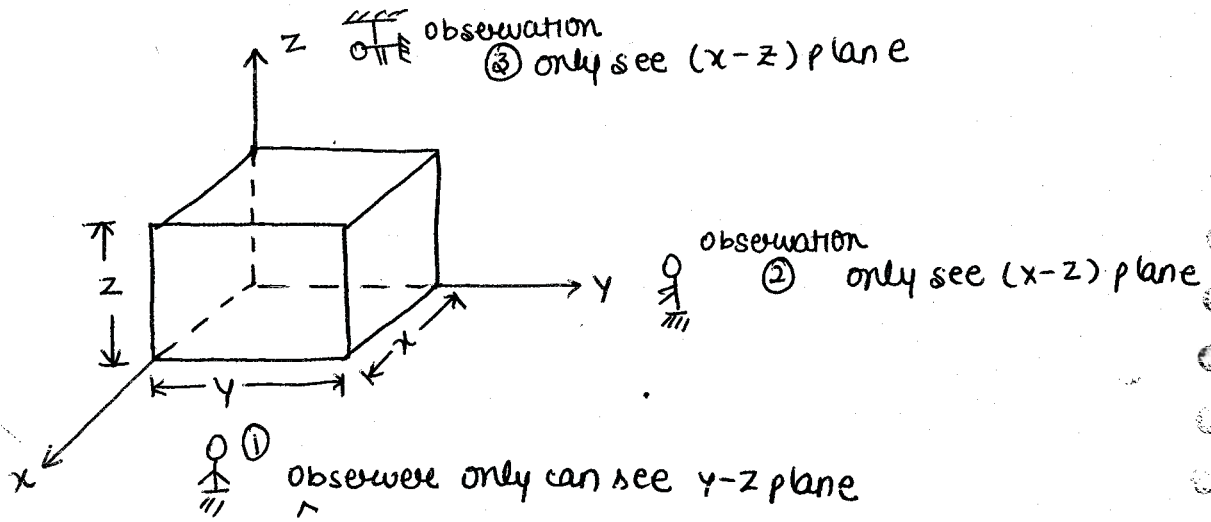


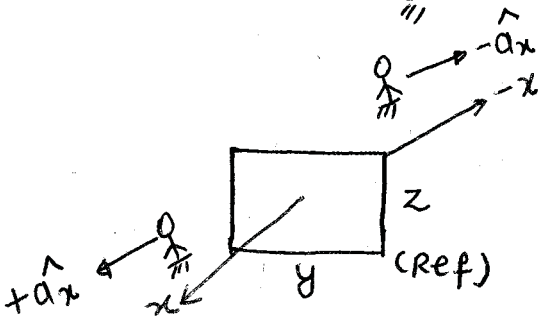
-: cy·co·system :-



-: sp·co·system :-

cartesian co-ordinate system :- (x, y, z)

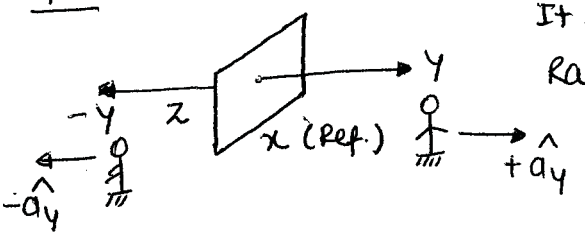




x :- Perpendicular distance from yz plane

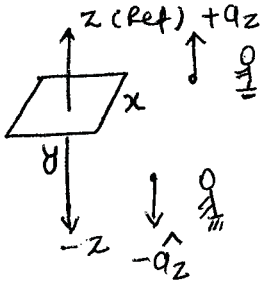
Range : $(\infty, -\infty)$

y :-



It is perpendicular distance from (x-z) plane
Range : $(-\infty, \infty)$

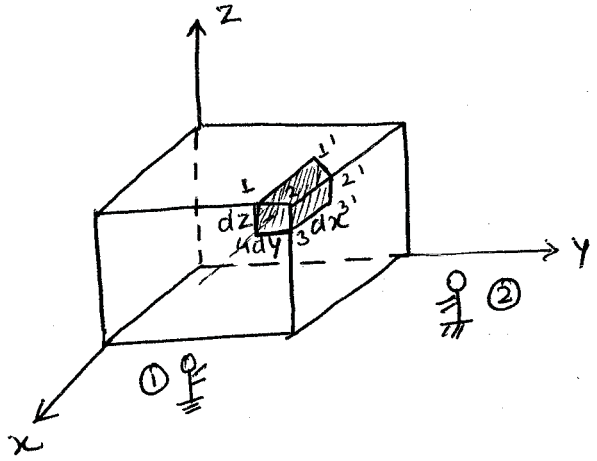
z :-



It is perpendicular distance from (x-y) plane.
Range : $(-\infty, \infty)$

concept of differential length, Area and volume :-

Graphical approach :-



Differential length dl :-

Differential length along x-axis = $dx\hat{a}_x$

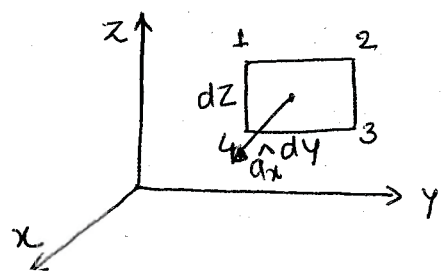
Differential length along y-axis = $dy\hat{a}_y$

Differential length along z-axis = $dz\hat{a}_z$

$$\therefore \boxed{\vec{dl} = dx\hat{a}_x + dy\hat{a}_y + dz\hat{a}_z}$$

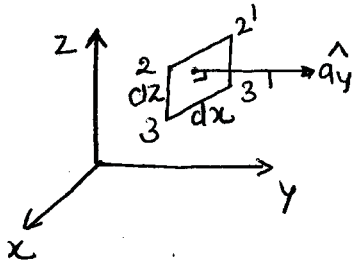
Differential surface area ds :-

observer ①



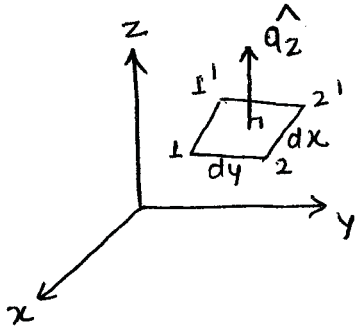
$$\boxed{\vec{ds} = dydz\hat{a}_x}$$

Observer ②



$$\vec{ds} = dx \cdot dz \cdot \hat{a}_y$$

Observer ③



$$\vec{ds} = dx\,dy\,\hat{a}_z$$

where area vectors are $\hat{a}_x$, $\hat{a}_y$, $\hat{a}_z$. which is always away from the surface.

NOTE:- The direction of area vector is always taken normal to the surface and away from the surface.

Differential volume, dv (scalar quantity):-

$$dV = dx\,dy\,dz$$

Analytical approach:-

$$dl = dx\,\hat{a}_x + dy\,\hat{a}_y + dz\,\hat{a}_z$$

$$= 1 \times dx\,\hat{a}_x + 1 \times dy\,\hat{a}_y + 1 \times dz\,\hat{a}_z$$

$$= h_1 \times du\,\hat{a}_u + h_2 \times dv\,\hat{a}_v + h_3 \times dw\,\hat{a}_w$$

u, v, w = parameter

h_1, h_2, h_3 = scaling factor

Hence,

Imp

	$\hat{a}_u$	$\hat{a}_v$	$\hat{a}_w$	du	dv	dw	h_1	h_2	h_3
1.co-system:	$\hat{a}_x$	$\hat{a}_y$	$\hat{a}_z$	dx	dy	dz	1	1	1

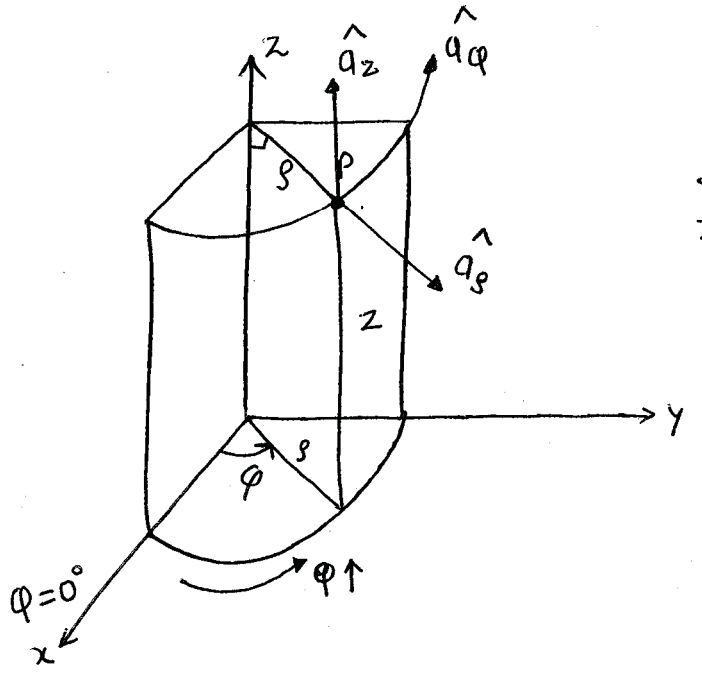
$$dl = dx\,\hat{a}_x + dy\,\hat{a}_y + dz\,\hat{a}_z$$

$$dS = 1 \times 1 \times dy\,dz\,\hat{a}_x$$ [Find area in direction of $\hat{a}_x$ Then freeze the $\hat{a}_x$ & dx & 1]

$dS = 1 \times 1\, dx\, dy\, \hat{a}_z$ [Find area in direction of $\hat{a}_z$]

$dV = 1 \times 1 \times 1 \times dx\, dy\, dz = dx\, dy\, dz$

Cylindrical co-ordinate system $\{\rho, \varphi, z\}$:-



ρ = radius of cylinder

z = Height

$\overline{A_P} = A_u \hat{a}_u + A_v \hat{a}_v + A_w \hat{a}_w$; u, v, w = parameter

$\overline{A_P} = A_\rho \hat{a}_\rho + A_\varphi \hat{a}_\varphi + A_z \hat{a}_z$

→ **ρ** : It is the **perpendicular distance** from **reference axis {z-axis}**
Range of ρ : $[0, \infty)$

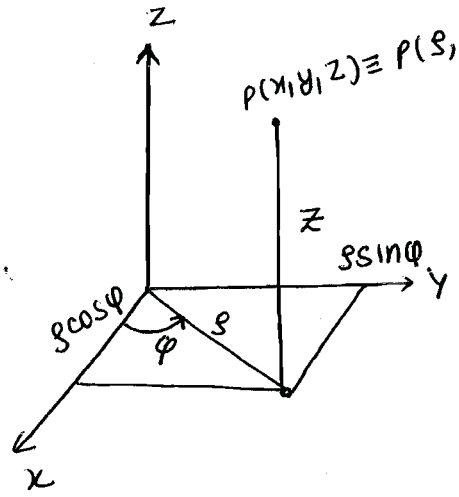
→ **φ** : **orientation angle** of point **about z-axis** and is always measured with respect to x-axis i.e., @ x-axis, $\varphi = 0°$ [Also known as azimuthal angle]
Range of φ : $[0, 2\pi]$

→ **z** : It is **Height of point along z-axis**.
Range of z : $(-\infty, \infty)$

Relation between cartesian coordinate system and cylindrical co-ordinate system :-

(i) In terms of parameters :

$$x = \rho\cos\varphi$$
$$y = \rho\sin\varphi$$
$$z = z$$



Now;

$$x^2 + y^2 = \rho^2\cos^2\varphi + \rho^2\sin^2\varphi = \rho^2$$

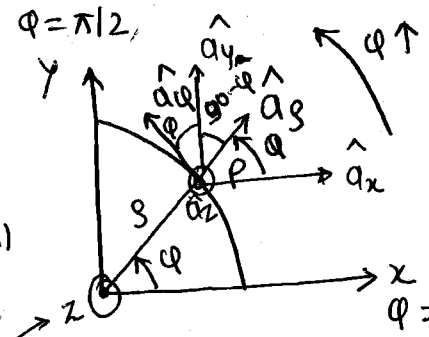
$$x^2 + y^2 = \rho^2$$

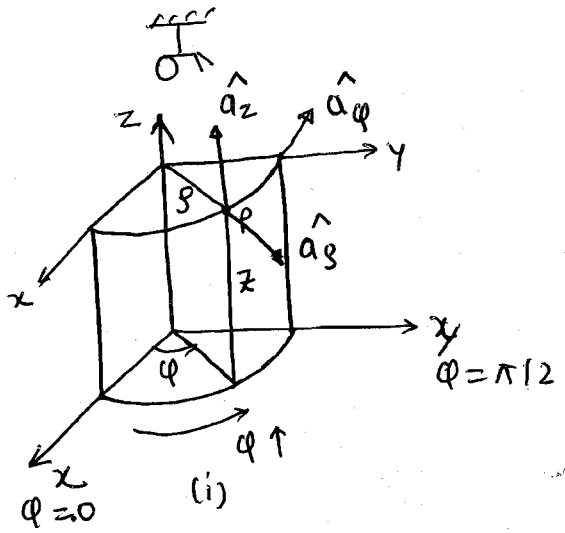
$$\boxed{\rho = \sqrt{x^2+y^2}}$$

Also; $\frac{y}{x} = \frac{\rho\sin\varphi}{\rho\cos\varphi} = \tan\varphi \Rightarrow \boxed{\varphi = \tan^{-1}(y/x)}$

And ; $\boxed{z = z}$

(ii) In terms of unit vector :-





-: Top view :-

$a_\rho \wedge a_\varphi = 90°$

$90+\varphi$

$\hat{a}_\rho \cdot \hat{a}_x = \cos\varphi$

$\hat{a}_\rho \cdot \hat{a}_y = \cos(90-\varphi) = \sin\varphi$

$\hat{a}_\rho \cdot \hat{a}_z = 0$ ($90°$)

$\hat{a}_\varphi \cdot \hat{a}_x = \cos(90+\varphi) = -\sin\varphi$

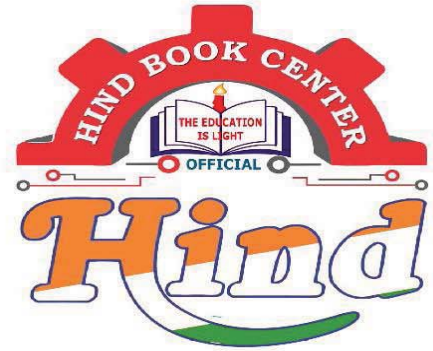
$\hat{a}_\varphi \cdot \hat{a}_y = \cos\varphi$

$\hat{a}_\varphi \cdot \hat{a}_z = \cos 90° = 0$

$\hat{a}_z \cdot \hat{a}_x = \cos 90° = 0$

$\hat{a}_z \cdot \hat{a}_y = \cos 90° = 0$

$\hat{a}_z \cdot \hat{a}_z = \cos 0° = 1$



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Introduction

#Boolean Logical Ideas –

These are categorized into 3 ways –

1) Producing the constants → (0,1) (Null, Identity)
2) Unary operations (transfer, complimentary)
   ↓ Buffer ↓ NOT
3) Binary operations (AND, OR, NAND, NOR, EXOR, EXNOR, Inhibition, Implication)

Note. For an input variables we get 2^n combinations and 2^{2n} (2^{2^n}) possible functions.

#Truth table –

x	y	f_0	f_1	f_2	f_3	f_4	f_5	f_6	f_7	f_8	f_9	f_{10}	f_{11}	f_{12}	f_{13}	f_{14}
0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1
0	1	0	0	0	0	1	1	1	1	0	0	0	0	1	1	1
1	0	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1
1	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0

→ $f_0 = 0$ Null

→ $f_1 = x \cdot y$ AND
$x \cap y$

→ $f_2 = x \cdot \bar{y}$ Inhibition
x / y [x but not y]

→ $f_3 = x$ transfer [Buffer]

→ $f_4 = \bar{x} \cdot y$ Inhibition
y / x [y but not x]

→ $f_5 = y$ Buffer

→ $f_6 = R \oplus y$ Ex-OR
$= \bar{x}y + x\bar{y}$

S_2	S_1	$S_2 \oplus S_1$ Bulb
0	0	0
0	1	1
1	0	1
1	1	0

Note. For the staircase an escalator & Ex-OR logic is used.

→ $f_7 = x + y$ OR
$x \cup y$

→ $f_8 = \overline{x+y}$ NOR
$x \downarrow y$

→ $f_9 = x \odot y$ **Ex-NOR**

$= \bar{x}\bar{y} + xy$

→ $f_{14} = \overline{x \cdot y}$ **NAND**

$x \uparrow y$

Note– Ex-NOR is also known as coincidence logic gates or equivalence logic gate.

→ $f_{15} = 1$ **Identity**

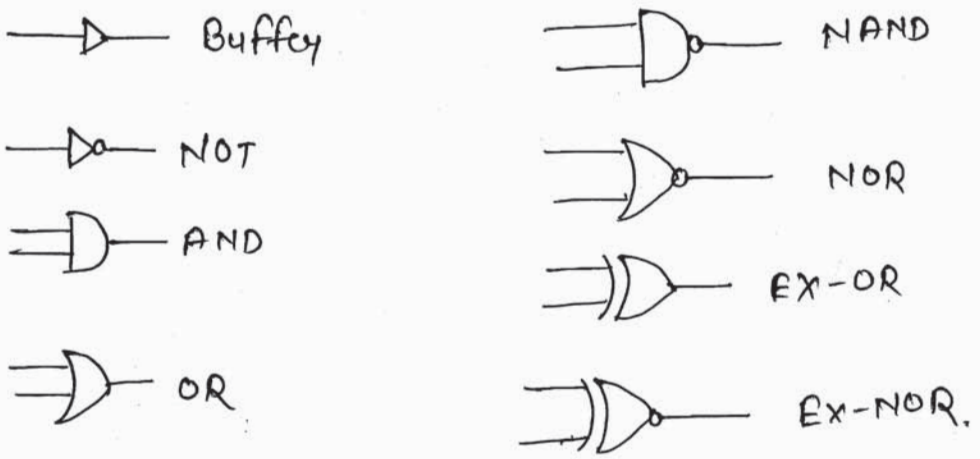
→ $f_{10} = \bar{y}$ **NOT**

→ $f_{11} = x + \bar{y}$ **Implication**

→ $f_{12} = \bar{x}$ **NOT**

→ $f_{13} = \bar{x} + y$ **Implication**

Logic Gate Symbols

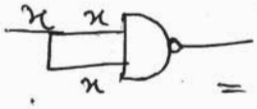


→ Basic logic gates – NOT, AND, OR

Universal logic gates– NAND, NOR

E.g.





$\overline{x \cdot x}$

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

$= \bar{x}$

Trick / Short-cut.

	NAND ← 4 → NOR
NOT	1 — 1
AND	2 — 3
OR	3 — 2
EX-OR	4 — 5
EX-NOR	5 — 4

Duality

Step-1 Interchange the operator → (· , +)

Step-2 Interchange the identity → (0 , 1)

AND	OR
$x \cdot x = x$	$x + x = x$
$x \cdot 0 = 0$	$x + 0 = x$
$x \cdot 1 = x$	$x + \bar{x} = 1$
$x \cdot \bar{x} = 0$	$x + 1 = 1$

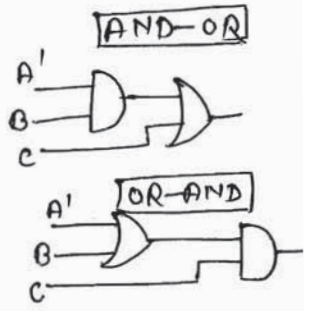
E.g: i) $x \cdot 0 = 0$

$x + 1 = 1$

ii) $F = A'B + C$

$F^D = ?$

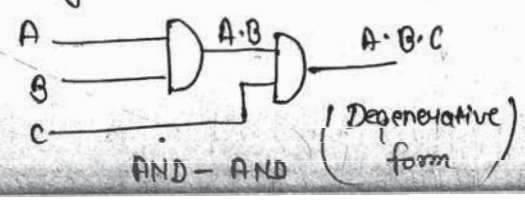
$F^D = (A+B) \cdot C$

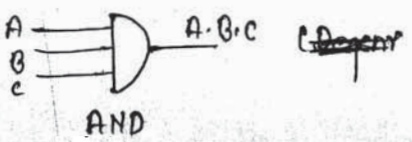


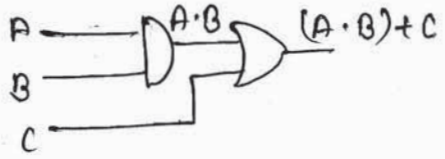
Degenerative forms

When a two level logic gate system o/p is expressed with a single logic gate then the two level logic gate system is known as degenerated form for the single logic gate.

E.g:







Non-degenerative form.

* Shortcut

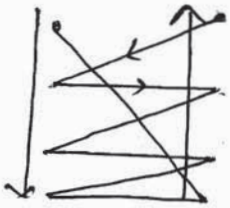
AND – OR OR – AND

NAND – NAND

NOR – OR NOR – NOR

NAND – AND

OR – NAND AND – NOR

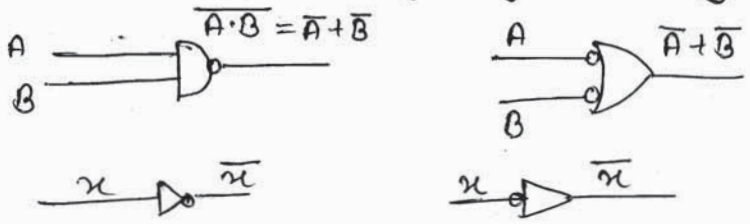


These are non-degenerative forms.

→ In the above representation, combinations present in the same horizontal line are dual forms.

Alternative logic gate ~~setting~~

Eg.



* Shortcut

NAND bubbled → OR

NOR → AND

AND → NOR

OR → NAND

Complimenting a boolean expression

1 - Dual form

2 - Complimenting the individual variable.

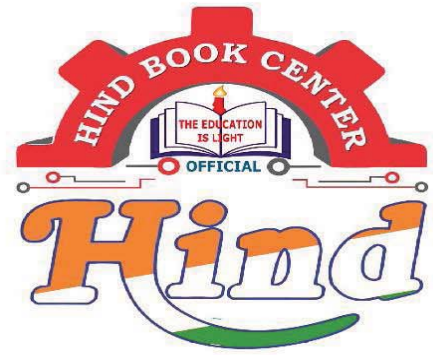
Eg.. $f = \overline{A} \cdot B + C$

$\overline{F} = ?$

(1) $(\overline{A}+B) \cdot C$

(2) $(A+\overline{B}) \cdot \overline{C} = \overline{F}$

(3) =



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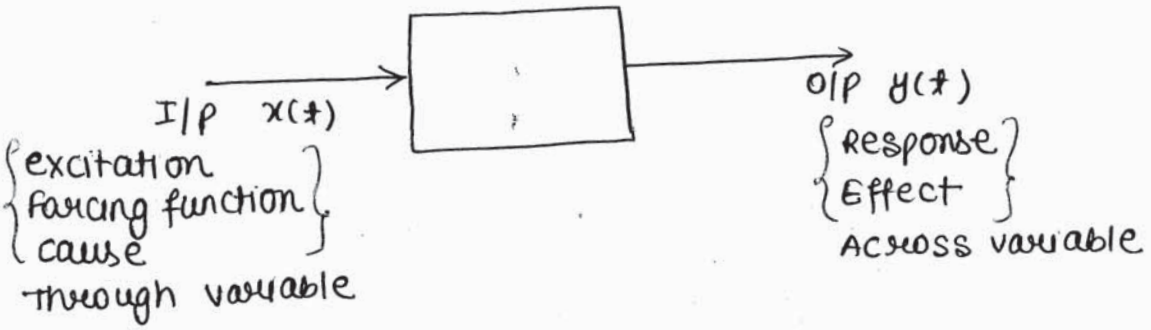
System :- The means of transforming a signal.

Signal is a form of energy that contains information of some phenomenon. Mathematically, signal can be defined as one are more number of independent variables.

Ex-: Speech $= f(t)$ Room temperature $= f(x, y, h, t)$

Image $= f(x, y)$

video $= f(x, y, t)$



$$y(t) = T[x(t)]$$

Control system :- Control system is that means by which any quantity of interest is maintained or altered according to a desire manner.

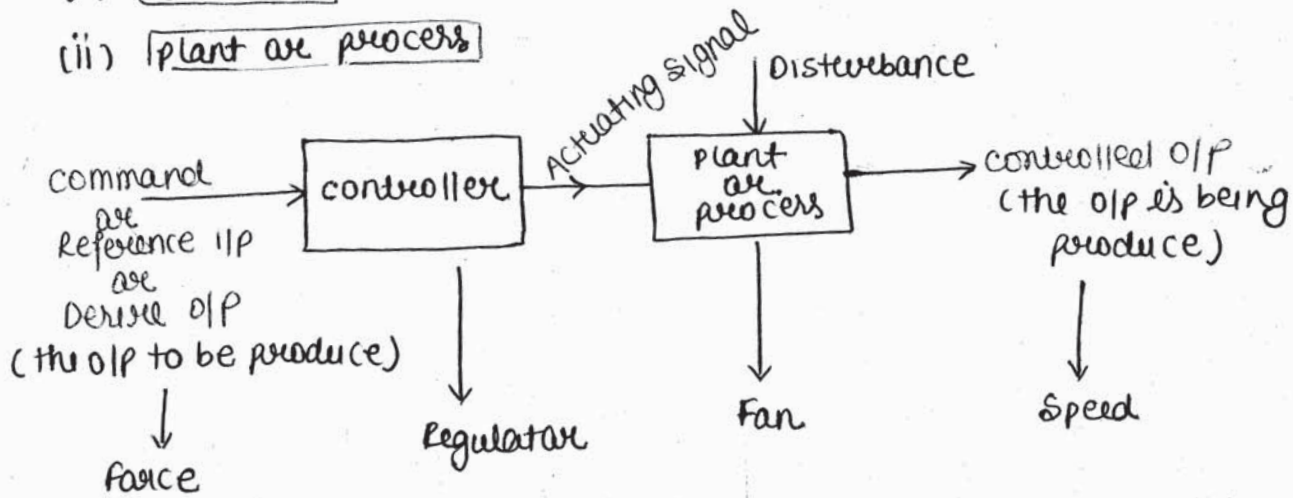
Ex-: system : J/K F/F

master slave F/F : control system

To make control system we need basically two element -

(i) controller

(ii) plant are process



SISO :-

MISO -:

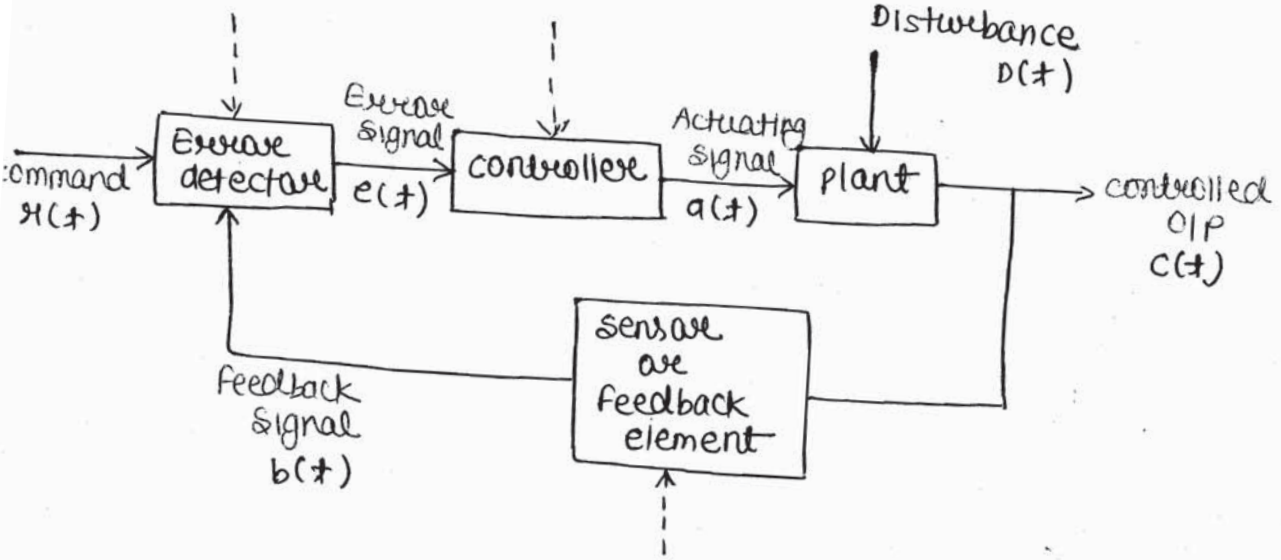
MIMO :- Automobile

SIMO -:

the objective of any control system is to ensure that **controlled output** become **same as** **desire o/p** this state of the system is called **steady state**.

without disturbance, control system is Ideal. but in practical system, there will be disturbance along with it.

practical control system :-



$C(s) = C_R(s) + C_D(s)$ [linear combination because $R(s)$ & $D(s)$ both are independent to each other]

Disturbation = Distortion + Noise

↓ Internal disturbance

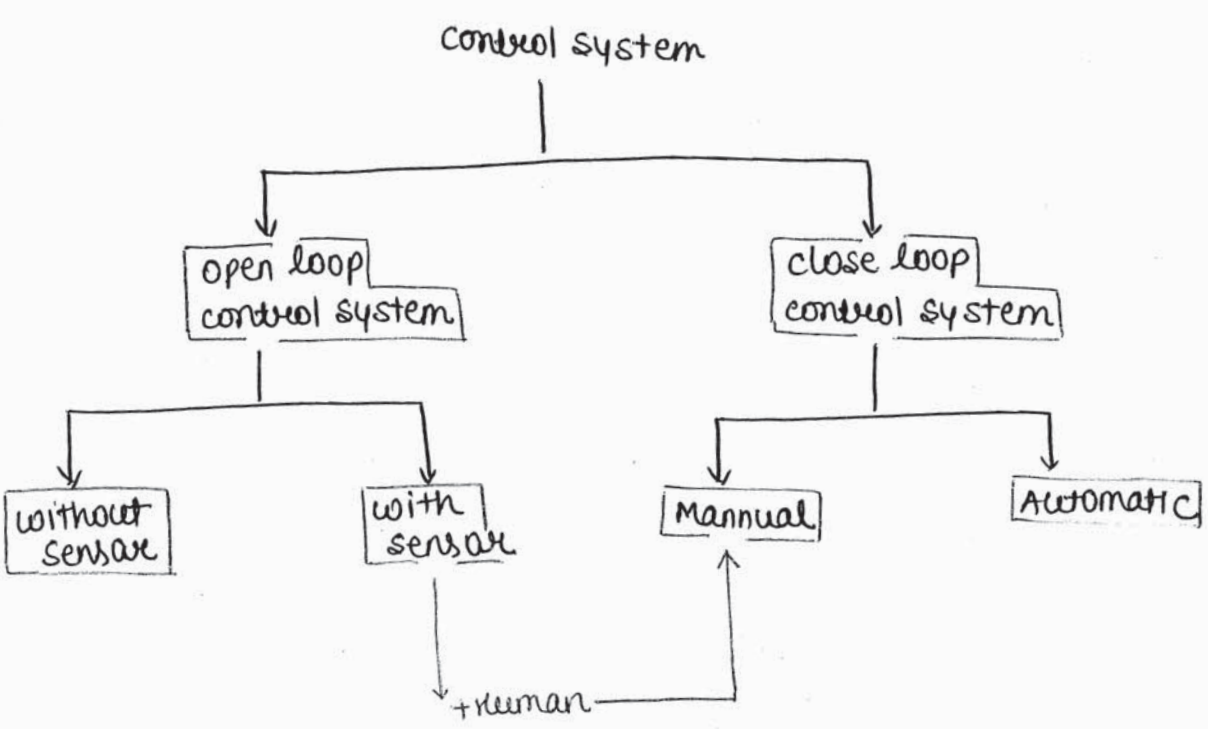
↓ External disturbance

Above system can overcome, the effect of disturbance associated only with the plant whereas the other disturbances still continues. Hence a system can attain steady state but not with 100% output within finite time.

$+10 = 10\angle 0^\circ$ ⟶ +ve feedback i.e; in phase

$-10\,V = 10\angle 180^\circ$ ⟶ -ve feedback i.e; out of phase

control system is classified into two categories -



Differences between open loop and close loop system :-

open loop control system	close loop control system
(i) The behaviour of OLCS does not change, though its output changes. Hence OLCS is not accurate	(i) The behaviour of close loop system if it output changes. Hence CLCS is accurate.
(ii) open loop system may or may not have sensor but it does not have complete sense.	(ii) Close loop system has complete sense either manually or Automatically.
(iii) Time constant of open loop system is larger, due to which transients takes large time to die out. Hence open loop system is slow.	(iii) Time constant of close loop system is smaller, due to which transients die out rapidly Hence close loop system is faster.
(iv) Effect of external disturbance and internal parameter variation is more in OLCS i.e; OLCS is more sensitive.	(iv) Effect of external disturbance and internal parameter variation is less in close loop system. i.e; close loop syster is less sensitive.
(v) The OLCS is generally stable but can be stabilize when it becoming unstable.	(v) Close loop system can become unstable but can be stabilized.
(vi) OLCS is simple & economical	(vi) CLCS is complex & expensive.

NOTE-: (i) The transient in system are due to stored energy / change in i/p / change in load condition

(ii) sequence of step to stabilize a system -

Step 1 -: Apply feedback. preferably negative feedback.

Step 2 -: Adjust system parameters preferably open loop gain.

Step 3 -: Insert a controller/ compensator preferably P+D controller/ lead compensator.

Ste

(iii) A system can be stable or unstable or marginally stable with any feedback, but a system is always more stable with a negative feedback compared to positive feedback.

(iv) Inspite of having negative feedback, control system can still become unstable due to high open loop gain / high type number / High sensitivity / High transportan delay or lag phase.

By default we have to consider — will be close loop control system.

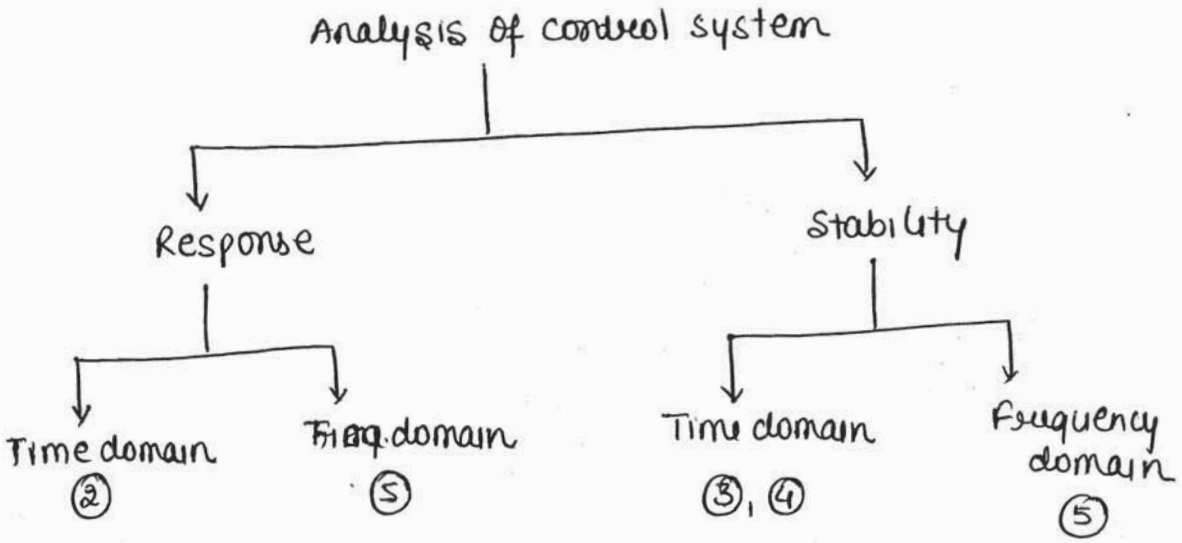
parameter	$\angle L180°$ -ve F.B.	$\angle L0°$ +ve F.B.
Gain	↓	↑
Bandwidth	↑	↓
Time constant	↓	↑
Speed	↑	↓
sensitivity	↓	↑
stability	↑	↓

Gain x Bandwidth = constant Time constant x speed = constant

sensitivity x stability = constant

(i) study the system design
(ii) Redesign
} mathematically

standard model :-
(i) T|F model (only for LTI)
(ii) state model (Any system)



Redesign — (6)
state model — (7)

	T.D.	F.D.
C.T. System	L.T.	F.T.
D.T. System	Z.T.	D.T.F.T.

L.T. :- Laplace transform
F.T :- fourier transform
Z.T :- Z- transform
DTFT : Discrete time fourier transform.

$$T.F. = \frac{L[O/P]}{L[I/P]}$$ | initial condition = 0

Total response = ZIR + ZSR (ZSR → 0)

- due to initial condition / state
- due to i/p

ZIR – zero i/p response i.e., i/p = 0

ZSR – zero state response

$$Y = C + mx$$

mx → due to i/p because x is a part of it.

NOTE:- ZIR is consider then analysis will be done in state model only.

Zero state response

- Transient or Dynamic Response
- steady state or Static Response

$$T.F. = \frac{L[O/P]}{L[I/P]} = \frac{L[IR]}{L[\delta(t)]} = \frac{L[SR]}{L[u(t)]} = \frac{L[RR]}{L[tu(t)]} = \frac{L[PR]}{L\left[\frac{t^2}{2}u(t)\right]}$$

$$T.F. = L[IR] = SL[SR] = S^2L[RR] = S^3L[PR]$$

Q.N:- $SR = 1 - 10e^{-t}$ then T.F. = ?

Solution:- $T.F. = SL[SR]$

$$= S\left[\frac{1}{S} - \frac{10}{S+1}\right] = S\left[\frac{S+1-10}{S(S+1)}\right] = \frac{1-9S}{S+1}$$

$SR = (1-10e^{-t})\,u(t)$

$\frac{d}{dt}(SR) = IR$

NOW $IR = \delta(t) - 10\left[e^{-t}\delta(t) + u(t)\,e^{-t}(-1)\right]$

$= \delta(t) - 10\,\delta(t) + 10\,e^{-t}u(t)$

$= -9\delta(t) + 10e^{-t}u(t)$

$T.F. = L[IR]$

$= -9(1) + \frac{10}{s+1} = \frac{1-9s}{s+1}$ i.e; Transfer functi is unique functio

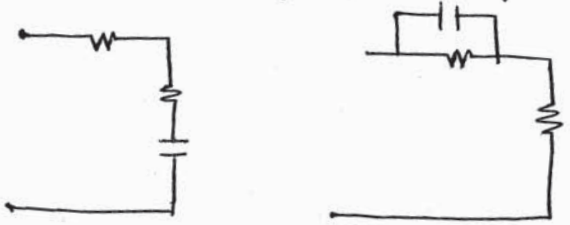
$SR = (1-10e^{-t})\,u(t)$

$RR = \int_0^t (SR)\,dt = \int_0^t (1-10e^{-t})\,u(t) =$

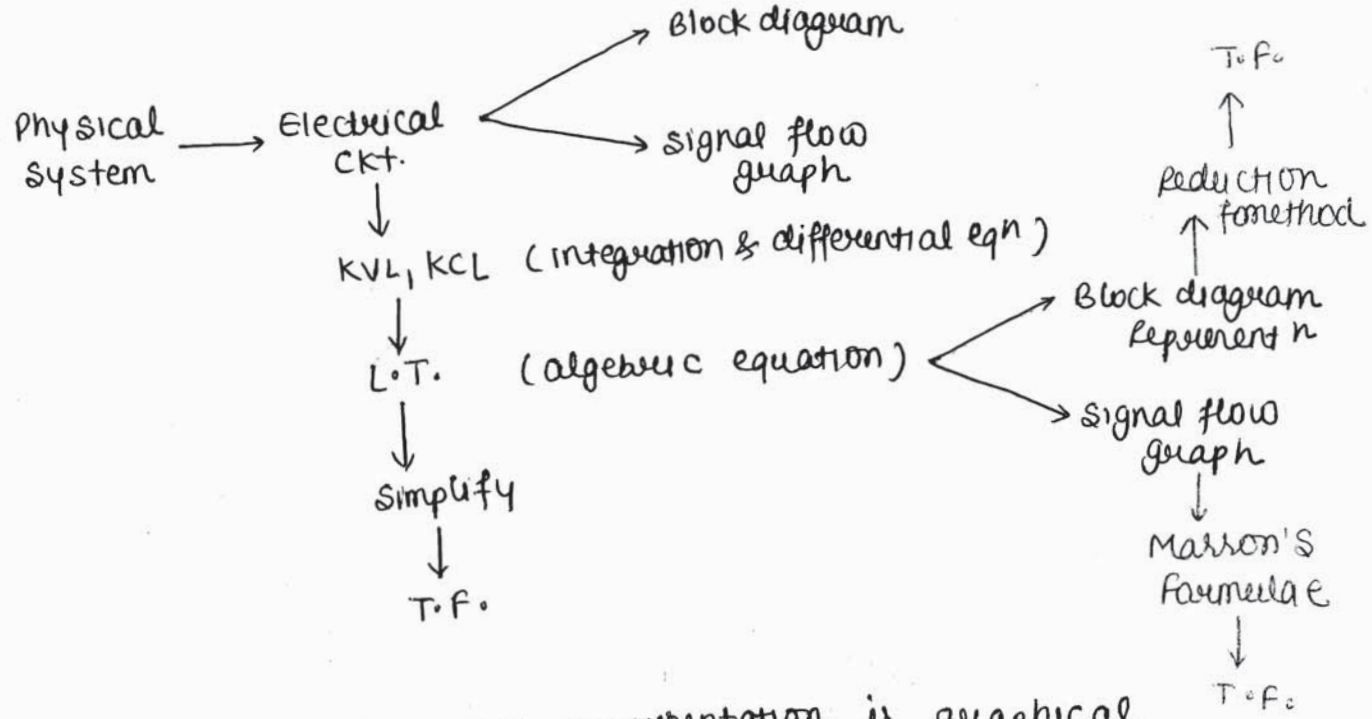
$SR\big|_{t=0} = (1-10e^{-t})\Big|_{@t=0} = -9 \neq 0$ i.e; it contains initial condition due to which it is not relaxed

if **initial condition** is **zero** then **L [Impulse response] = T.F.**

Transfer function of a system is **unique** i.e; one system can not have two transfer function but two or more number of different system may have the same transfer function. because transfer function depends on the component but not their configuration.



$\frac{s+a}{s+b}$



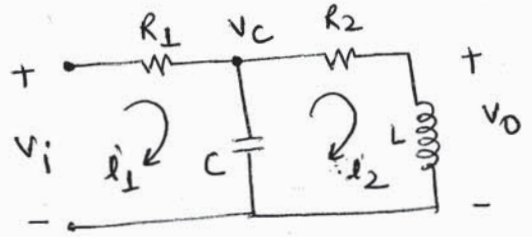
BDR, SFG: BDR or SFG representation is graphical representation of mathematical relation between the variables of a system described in the form of set of linear algebric equation in cause effect form.

Linear: $y = mx \longrightarrow$ BDR | SFG $\longrightarrow$ T.F.

Non linear: $y = mx + C \longrightarrow$ state diagram $\longrightarrow$ state model

$q = Cv$

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



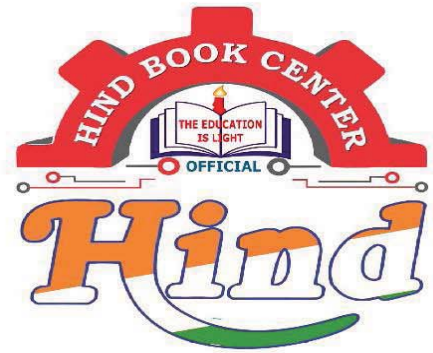
$$-V_i + i_1 R_1 + \int (i_1 - i_2)\cdot dt \cdot \frac{1}{C} = 0 \qquad -V_C + R_2 i_2 + V_0 = 0$$

not in cause effect form $\Leftarrow$ ~~$V_i = i_1 R_1 + \frac{1}{C}\int (i_1 - i_2)\,dt$~~

$$V_0 = (SL)\, i_2$$

$$\frac{V_i}{S} = R_1 \frac{i_1(S)}{S} + \frac{1}{CS}(i_1 - i_2)$$

$$\frac{V_i}{S} = \frac{R_1 i_1}{S} + \frac{i_1}{CS} - \frac{i_2}{CS}$$



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Chapters :-

1. signals definition and its classification
   - Even / Odd
   - Periodic / Non-periodic
   - conjugate symmetric & conjugate antisymmetric
   - Half wave symmetry
   - Energy and power signal

2. Different operations in signal
   - shifting
   - scaling
   - Reversal
   - Differentiation
   - Integration
   - convolution

3. Basic system properties
   - static / dynamic system
   - Linear / non-linear
   - causal / Non-causal
   - Stable / unstable
   - Time invariant / Time-varient
   - Invertible / Non-invertible

4. Fourier Series (continuous time)
5. Fourier Transform (continuous time)
6. Laplace Transform
7. Sampling Theorem
8. Discrete time signal & system
   - Types of signals
   - Basic signals
   - Different operations on signal
   - Types of systems

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9. Z-Transform ⟶ GATE + IES

10. Discrete fourier transform (DFT)
and
Fast fourier transform (FFT)

11. Digital filters
- → Infinite impulse response (IIR) filter
- → finite impulse response (FIR) filter
- → Impulse invariance method
- → Bilinear transformation method

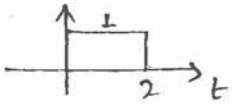
12. Discrete cosine transform (DCT)
⟶ IES only.

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Different operations on signal :-

(1) Time shifting :- → Left shifting
→ Right shifting

$x(t) \longrightarrow x(t+k)$



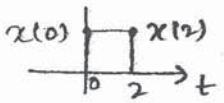
Case (i) :- When $k>0$ (Left shifting) :-

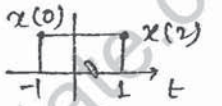
Example $k=1$

$x(t) \longrightarrow y(t) = x(t+1)$

$t=-1 \Rightarrow x(0)$

$t=1 \Rightarrow x(2)$





(Left shifting)

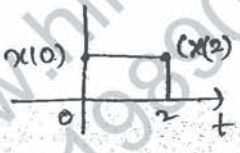
Case (ii) :- When $k<0$ (Right shifting) :-

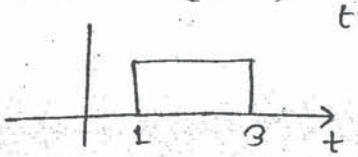
Example $k=-1$

$x(t) \longrightarrow y(t) = x(t-1)$

$t=1 \Rightarrow x(0)$

$t=3 \Rightarrow x(2)$



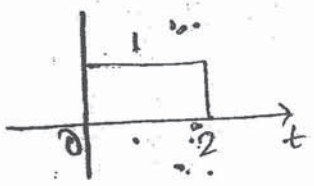


(Right shifting)

(2) Amplitude shifting :-

→ upward
→ downward

$x(t) \longrightarrow y(t) = k + x(t)$



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Case (i) When $K > 0$ (upward shifting)

Example $K = 1$

$$x(t) \longrightarrow 1 + x(t)$$

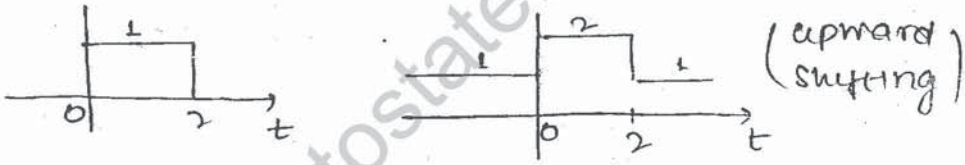
$$x(t) = \begin{cases} 0 ; & t < 0 \\ 1 ; & 0 \le t \le 2 \\ 0 ; & t > 2 \end{cases}$$

$$y(t) = 1 + x(t)$$

$$y(t) = \begin{cases} 1+0 ; & t < 0 \\ 1+1 ; & 1 \le t \le 2 \\ 1+0 ; & t > 2 \end{cases}$$

$$y(t) = \begin{cases} 1 ; & t < 0 \\ 2 ; & 1 \le t \le 2 \\ 1 ; & t > 2 \end{cases}$$

$$x(t) \longrightarrow y(t) = 1 + x(t)$$



(upward shifting)

Case (ii) When $K < 0$ (Downward shifting)

Example $K = -1$

$$x(t) \longrightarrow y(t) = -1 + x(t)$$

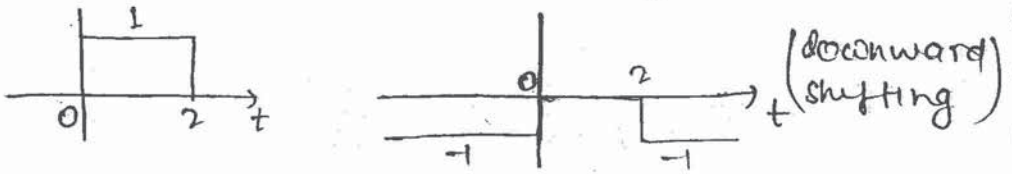
$$x(t) = \begin{cases} 0 ; & t < 0 \\ 1 ; & 0 \le t \le 2 \\ 0 ; & t > 2 \end{cases}$$

$$y(t) = -1 + x(t)$$

$$y(t) = \begin{cases} -1+0 ; & t < 0 \\ -1+1 ; & 0 \le t \le 2 \\ -1+0 ; & t > 2 \end{cases}$$

$$y(t) = \begin{cases} -1 ; & t < 0 \\ 0 ; & 1 \le t \le 2 \\ -1 ; & t > 2 \end{cases}$$

$$x(t) \longrightarrow y(t) = -1 + x(t)$$

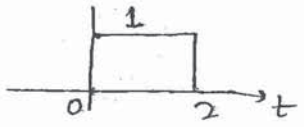


(Downward shifting)

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(3) Time - Scaling :-

$x(t) \longrightarrow x(at)$, $a \neq 0$.



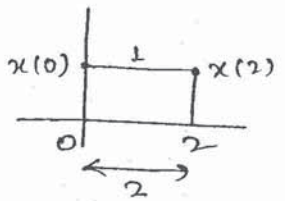
Case (i) when $a > 1$:- (time compression)

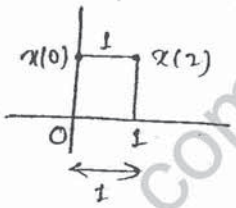
Example $a = 2$

$x(t) \longrightarrow x(2t)$

$t = 0 \rightarrow x(0)$

$t = 1 \rightarrow x(2)$



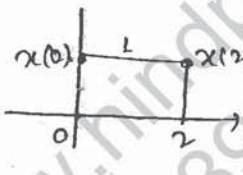


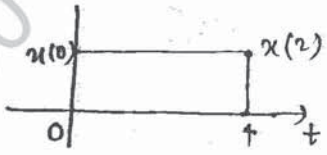
(time compression)

Case (ii) when $0 < a < 1$:- (time expansion)

Example $a = 0.5$

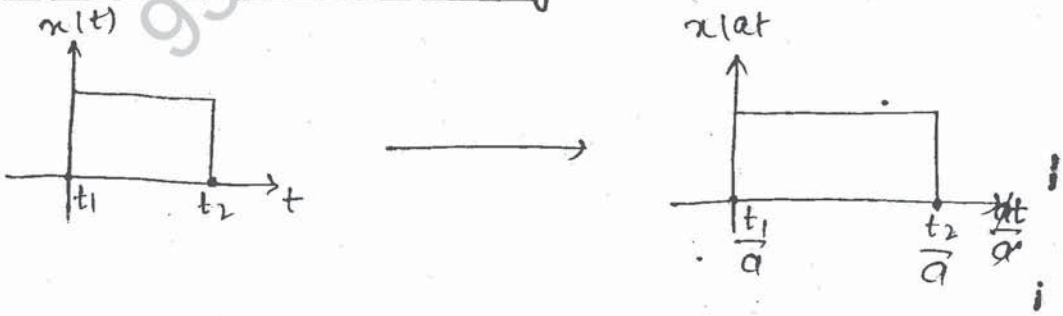
$x(t) \longrightarrow x(0.5t)$





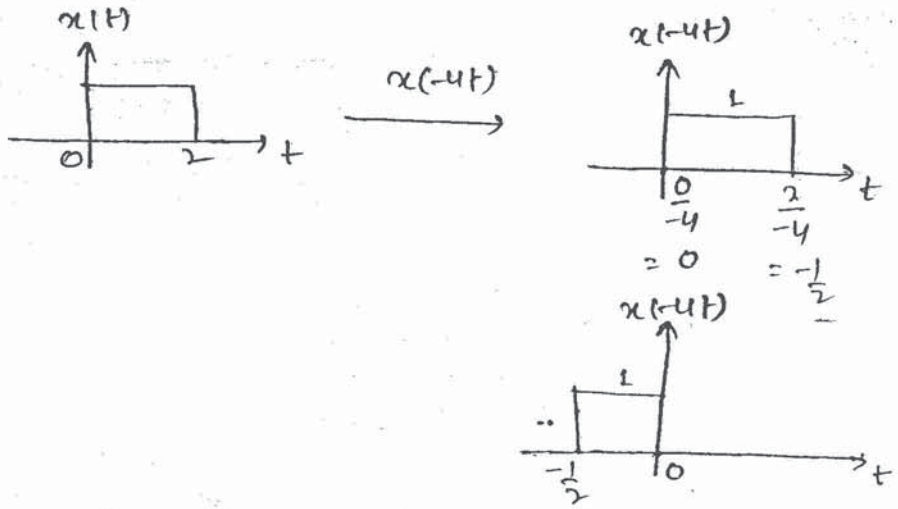
(time expansion)

General Rule for time Scaling :-

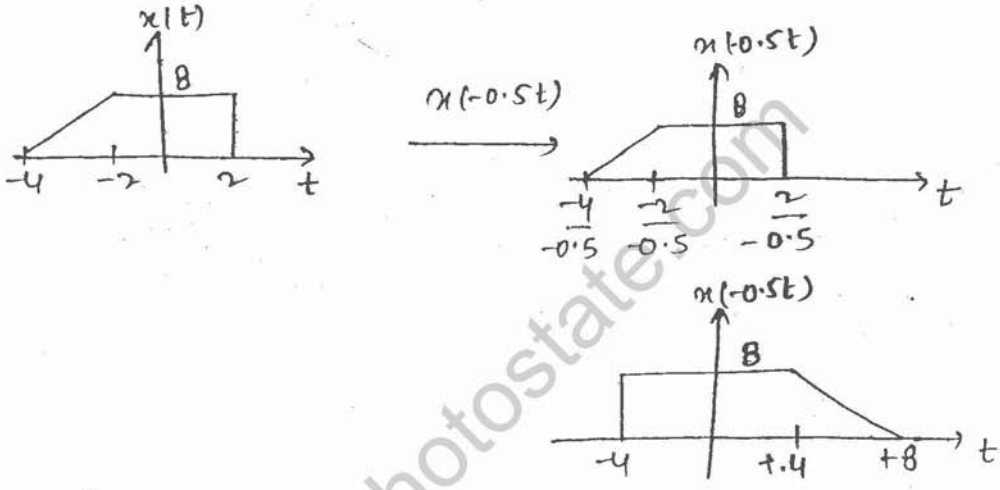


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Example :-



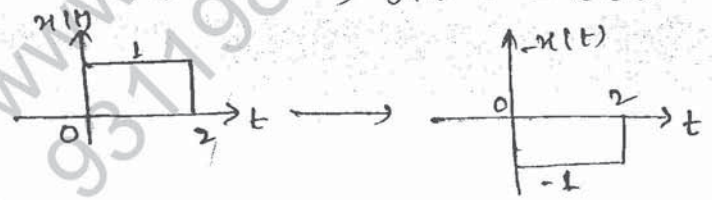
Example :



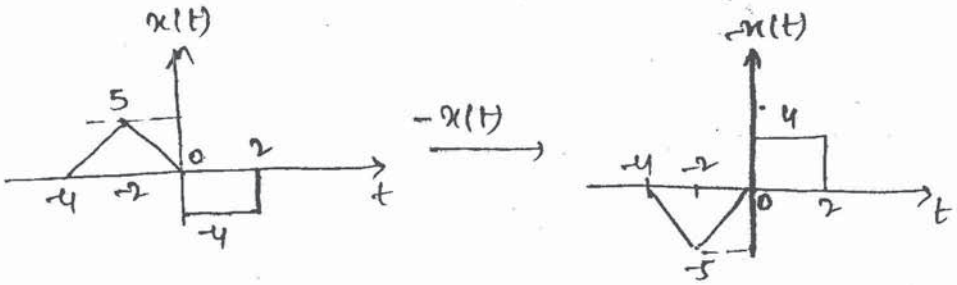
(4) Amplitude Reversal :-

(Folding about x axis)

$x(t) \longrightarrow y(t) = -x(t)$



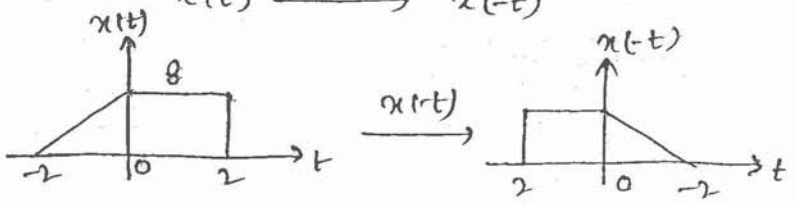
Example :-



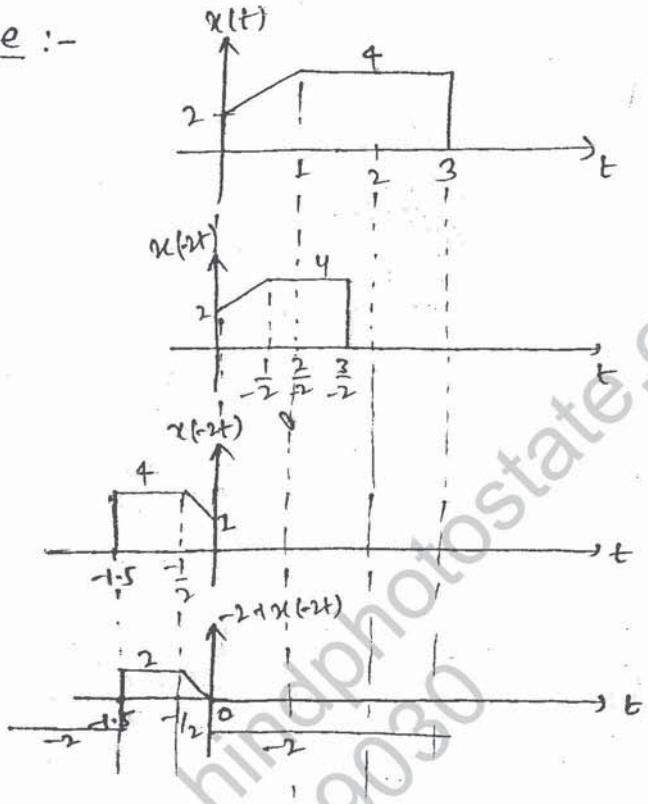
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(5) Time-Reversal :- (R diag about y-axis)

$x(t) \longrightarrow x(-t)$



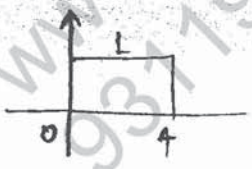
Example :-



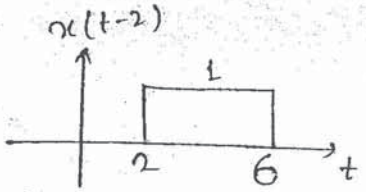
Find $y(t) = ?$

where $y(t) = -2 + x(-2$

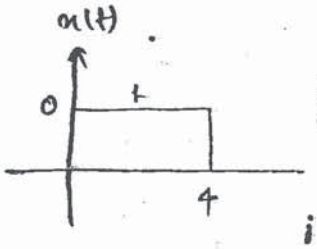
Example :- x(t)



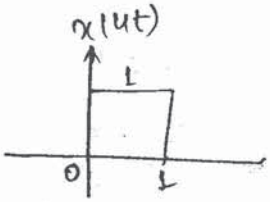
Right shift by 2



Example:

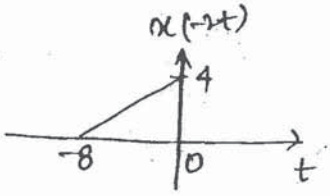


Divide x-axis by '4'

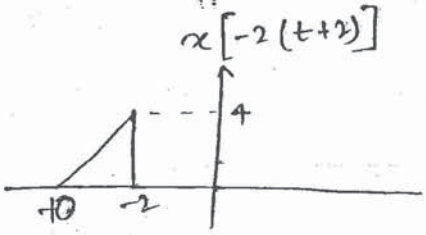


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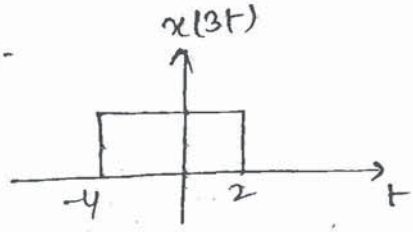
Example :-



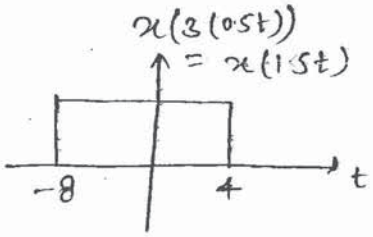
$t \to t+2$
Left shift by 2



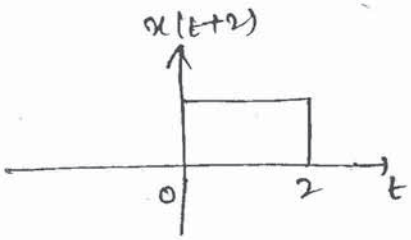
Example :-



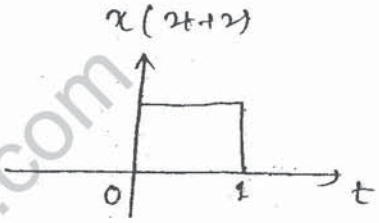
$t \to 0.5t$
divide x-axis by 0.5



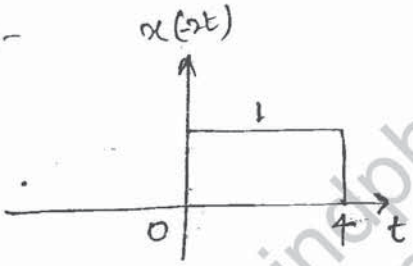
Example :-



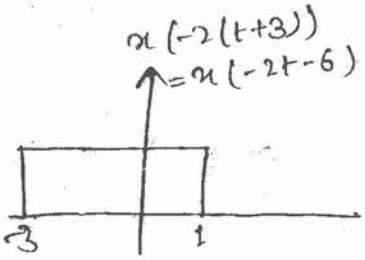
$t \to 2t$
divide x-axis by 2



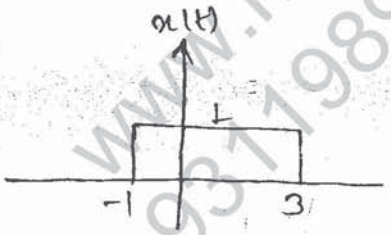
Example :-



$t \to t+3$
Left shift by 3



*** Question :



Draw signal $y(t)$

$y(t) = x(2t+3)$

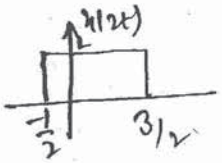
$= x(2(t+1.5))$

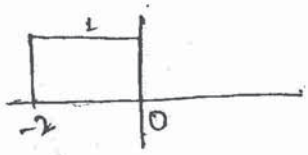
Solution :- method (1)

time scaling

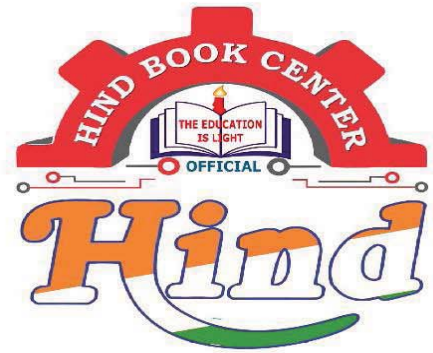
$x(t) \xrightarrow{\text{scaling}} x(2t) \xrightarrow{L.S = 1.5}$ यहाँ 3 से LS नहीं करेंगे।

$\to x(2t+3)$ or $x(2(t+1.5))$





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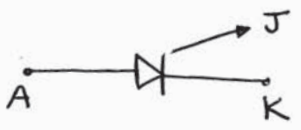
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-: Analog Electronics :-

-: Chapter-1 Diode models :-

Ideal model :-



Indication :

A → Anode (+)

K → cathode (-)

J → Junction

Arrow → unilateral device

↓

[impedance are different]

conditions for ideal model of diode :-

$V_A - V_K > 0$ then D = ON — S.C. — $V_D = 0$, $I_D > 0$

$V_A - V_K < 0$ then D = OFF — O.C. — $V_D = V_B$, $I_D = 0$

$V_A - V_K = 0$ then D just ON — S.C. — $V_D = 0$, $I_D = 0$

V_B = Battery voltage

Testing method to check diode status :-

a. Short circuit Test (SC Test) [Failure when KVL violates in the ckt]

b. open circuit Test (OC Test) [Failure when KCL violates in the ckt]

Procedure to check diode status using SC Test :-

Rule 1 :- Assume all the diodes to be S.C.

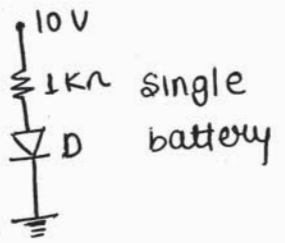
Rule 2 :- Indicate the current direction of each diode from A to K.

Rule 3 :- Check & calculate I_D of each diode by using KVL or KCL

Status : $I_D > 0$; D = ON

$I_D < 0$; D = OFF

Example 1: Check the status of diode D in the given ckt

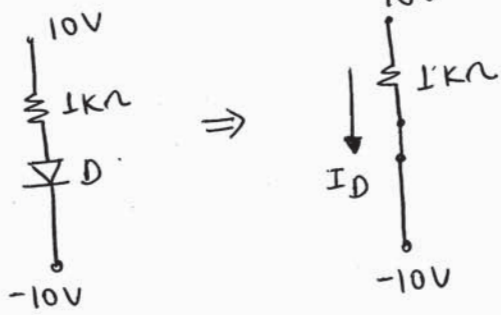


single battery



dual battery

Solution :-

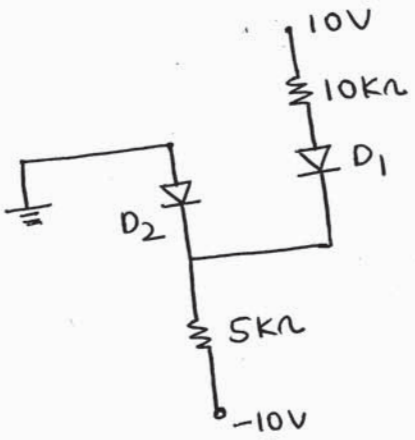


$$I_D = \frac{10-(-10)}{1K}$$

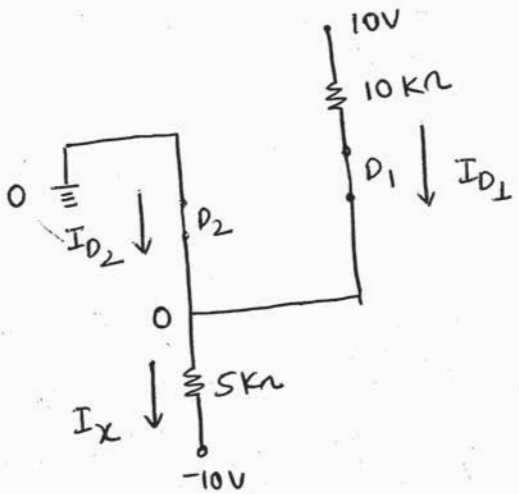
$$= 20mA > 0$$

$\hookrightarrow$ D ON

Example 2: check the status of D_1 & D_2 in the given ckt



Solution :-



$$I_{D_1} = \frac{10-(0)}{10K} = 1mA > 0$$

$\hookrightarrow$ D_1 ON

$$I_X = \frac{0-(-10)}{5K\Omega} = 2mA$$

KCL @ node 'a'

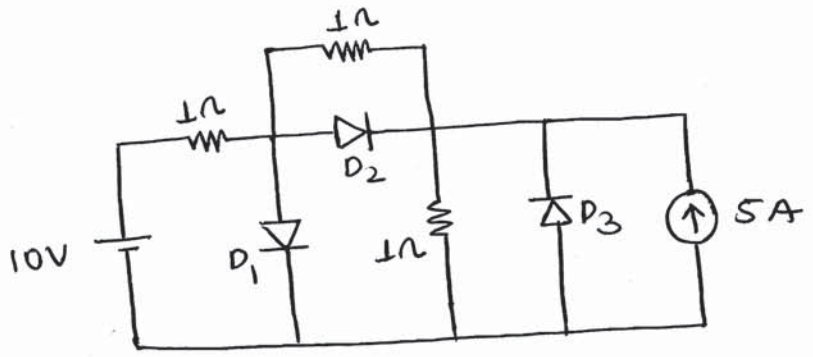
$$I_{D_1} + I_{D_2} = I_X$$

$$I_{D_2} = 2mA - 1mA$$

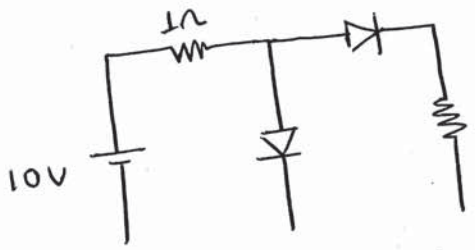
$$I_{D_2} = 1mA > 0$$

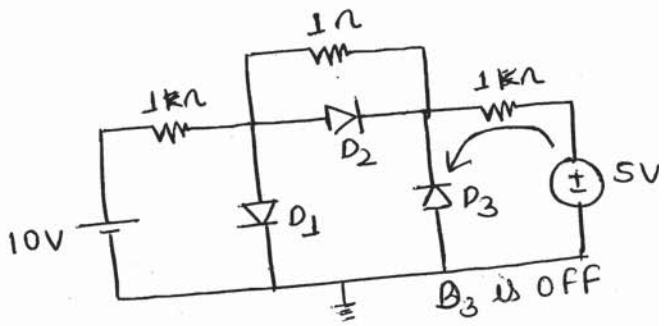
$\hookrightarrow$ D_2 ON

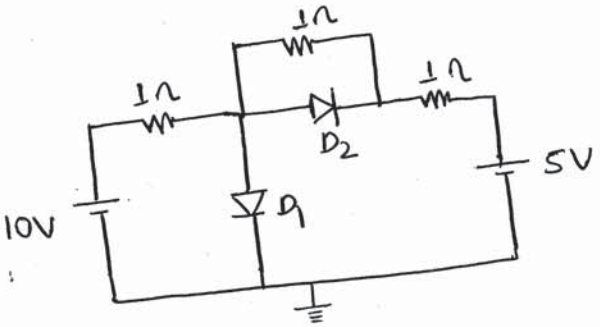
Q.N:- what are the states of the three ideal diodes of the circui

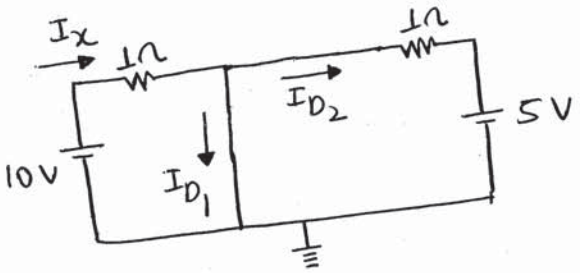


Solution:-









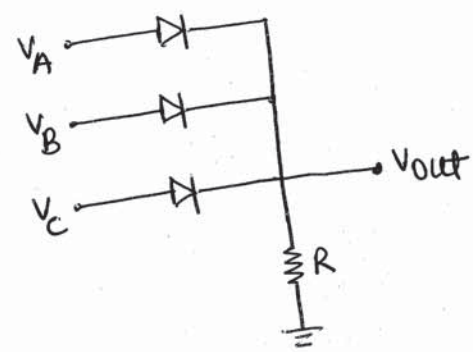
$I_x = \frac{10-0}{1} = 10A$ $\quad I_{D_2} = \frac{0-5}{1} = -5A < 0$ → D_2 is off

KCL at node a $\quad I_x = I_{D_1} + I_{D_2}$

$I_{D_1} = 10-(-5)$

$I_{D_1} = 15A > 0$ → D_1 is ON

Conclusion:-



$V_A = 5V$, $V_B = 3V$, $V_C = 1V$

Failure of KVL in the short circuit test.

It violates KVL

$V_{out} = 5$ volt

Procedure to check diode status using open circuit test :-

Rule 1 : Assume all the diodes to be OFF

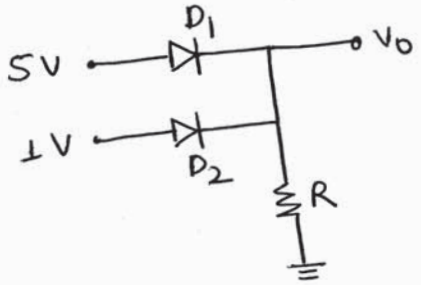
Rule 2 : Indicate V_A & V_K of each diodes

Rule 3 : Calculate $V_A - V_K$ difference of each diodes

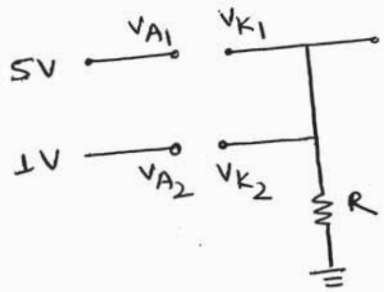
Status : $V_A - V_K > 0$ D = ON

$V_A - V_K < 0$ D = OFF

Example 1 :-



solution :-



$V_{A_1} - V_{K_1} = 5 - 0$

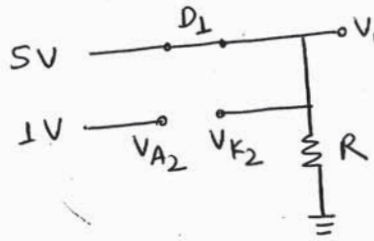
$= 5 > 0$

$V_{A_2} - V_{K_2} = 1 - 0$

$= 1 > 0$

Two diodes ON simultaneously then recheck condition

Select D_1 ON first because it is more FB



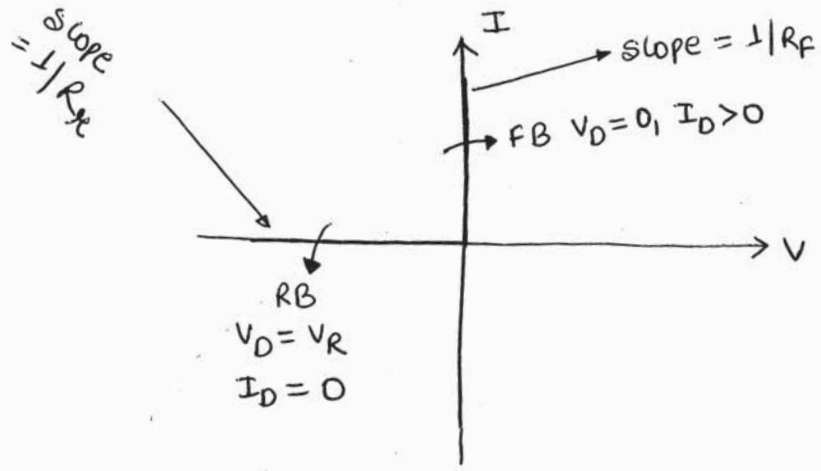
$V_{A_2} - V_{K_2} = 1 - 5$

$= -4 < 0$

$\rightarrow D_2$ become OFF

Highest voltage will be ON. first.

V-I characteristic of ideal diode :-



Indication : R_f = forward diode resistance

R_R = Reverse diode resistance

In forward bias : $\text{slope} = \frac{1}{R_f} = \infty \Rightarrow \boxed{R_f = 0}$ ideal diode

In reverse bias : $\text{slope} = \frac{1}{R_R} = 0 \Rightarrow \boxed{R_R = \infty}$ ideal diode

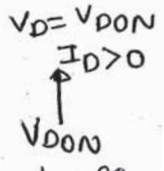
CVD model :-

CVD means constant voltage drop model

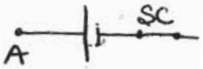
Practical diode will have cut in voltage V_γ.

V_γ (si) ⟶ 0.5 V to 0.7 V

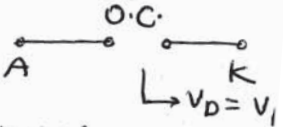
$V_D = V_\gamma$ then $V_D = V_{D,ON}$



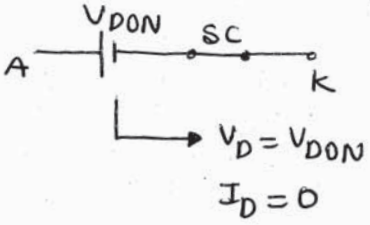
condition for CVD model :- $V_A - V_K > V_{D,ON}$ then D ON



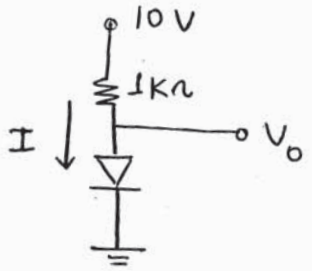
$V_A - V_K < V_{DON}$ then D = OFF



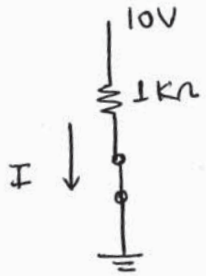
$V_A - V_K = V_{DON}$ then D just ON.



Ex 1 :- Check the status of diode and calculate V_o and I using Ideal & CVD model.



Solution :- Ideal condition :- [SC Test]

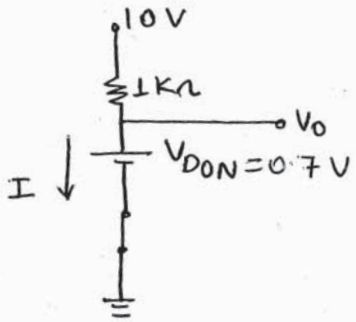


$$I = \frac{10-0}{1K}$$

$$= 10mA > 0 \text{ then } D \text{ ON}$$

$$V = 0,\ I = 10mA$$

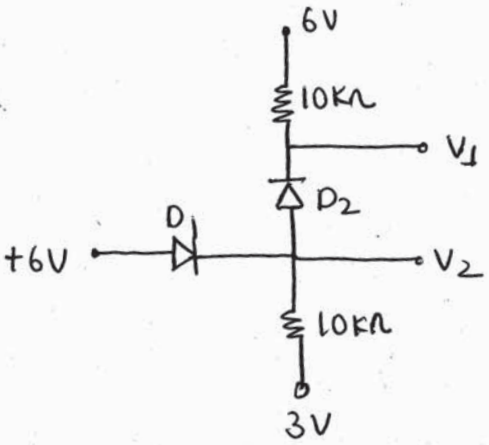
CVD condition :- [SC Test]



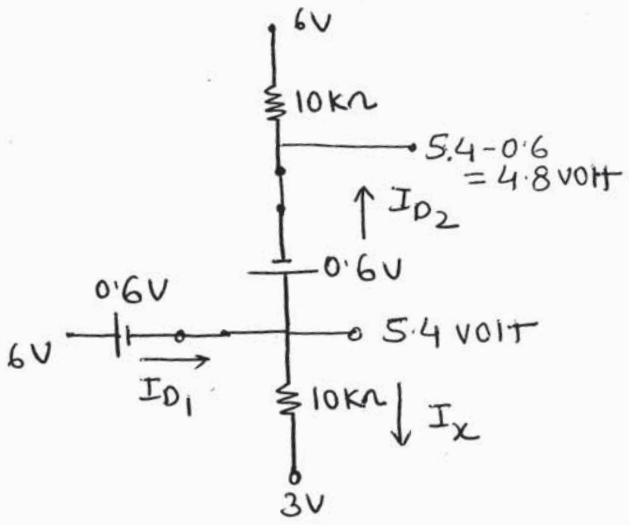
$$I = \frac{10-0.7}{1K} = 9.3mA > 0 \text{ then } D \text{ ON}$$

$$V_o = 0.7 \text{ volt},\ I = 9.3mA$$

Q.N:14 The voltage at V_1 & V_2 of the arrangement shown in figure will be respectively $V_\gamma = 0.6$ volt



Solution :-



$$I_x = \frac{5.4-3}{10K}$$

$$= 0.24\,mA$$

$$I_{D_2} = \frac{4.8-6}{10K}$$

$$= -0.12\,mA < 0$$

↳ D_2 is in OFF condition

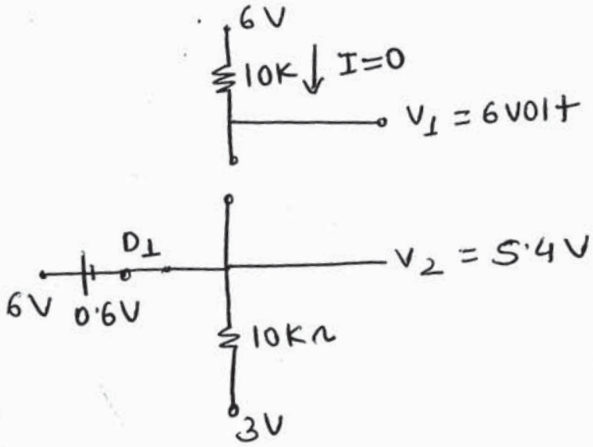
KCL @ 5.4V

$$I_{D_1} = I_{D_2} + I_x$$

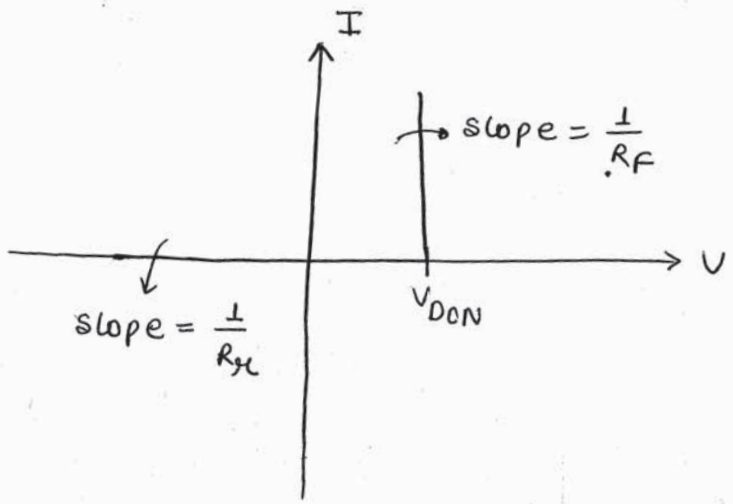
$$= -0.12 + 0.24$$

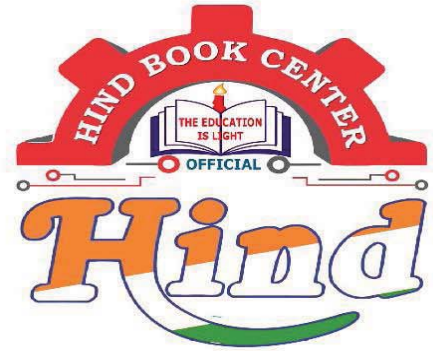
$$= 0.12\,mA > 0$$

↳ D_1 is in ON condition



V-I characteristic of CVD model :-





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Standard voltages used in India :-

HVAC RMS line to line voltage / line voltage (kV) :

Transmission Network voltage (kV) –
- 1200 KV (maximum in india) Maharashtra
- 765, 400
- 220, 132
- 66

Distribution Network voltages (kV) –
- 33 KV, 11 KV

Industrials uses – 6.6 KV, 3.3 KV, 1.1 KV, 400 V

Houses uses – 230 V (phase voltage)

Frequency $f = 50$ Hz

HVDC ± 500 KV, ± 800 KV, $f = 0$ Hz

Q.N:- The rated voltage of a 3-phase power system is –
– RMS line to line voltage

All India Installed capacity sector : 382.730 GW

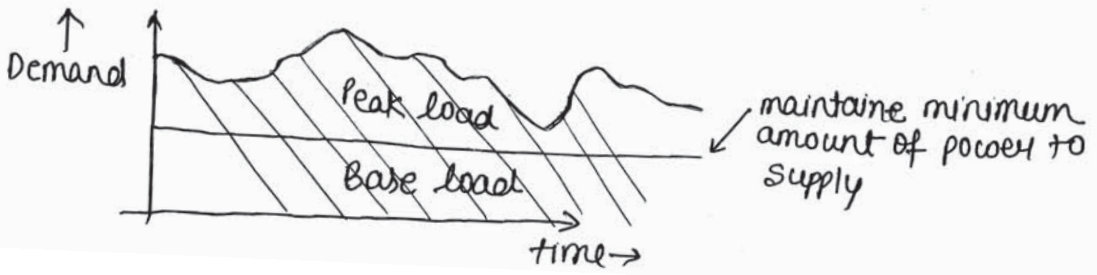
Coal : 209294.5 MW	Gas : 24924 MW	Nuclear : 6780 MW
Hydro : 46209.22 MW	Diesel : 509.71 MW	Renewable Energy source : 95012.59 MW

WR : 74320 MW by coal largest
NER : 770 MW by coal smallest
} power utilisation

Thermal : Coal + Lignite + Gas + Diesel

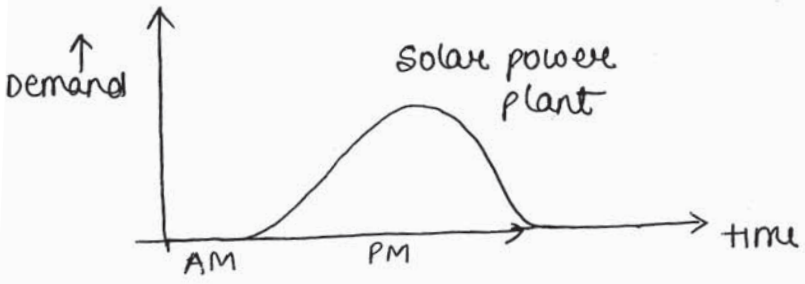
30th June 2021 → maximum power consumed by 193 GW at 12:46 pm

variable load curve : All india Demand (GW) v/s time



Base load –: Thermal plant Next to peak load : Gas, wind, solar

Peak load –: Hydro plant



1 Kwhr = 1 unit

2019-20 1208 Kwh per capita consumption

Objectives of Power system :-

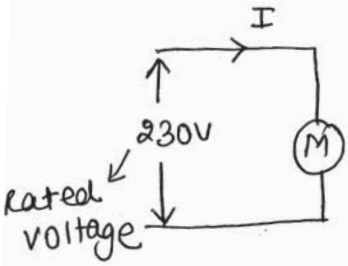
(i) **Cost** of **electric energy** must be **low**.

- Economic factors
- Economic load dispatch

(ii) **Reliable power supply** i.e, no interruption of power supply

- power generation methods
- Transmission
- Distribution
- Load flow studies

(iii) **Maintain constant voltage** i.e, supply rated voltage to consumer



$P = V I \cos\varphi$

$I = \frac{P}{V\cos\varphi} = \frac{230}{230 \times 0.8} = 1.25\,A$

suppose supply voltage get reduce to V = 200 volts then current drawn by motor will be $I = \frac{230}{200 \times 0.8} = 1.4375\,A.$

% increase in current $= \frac{1.4375 - 1.25}{1.25} \times 100 = 15\%$

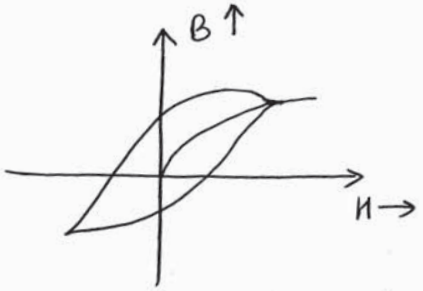
current drawn by motor is high value. this will causes overheating

To get constant voltage — voltage/Reactive power control

(iv) **Maintaine Rated frequency**

$f = 50Hz \pm 1\%$ (49.5 to 50.5) Hz (ideal case)

$= 50Hz \pm 3\%$ (48.5 to 51.3) Hz (practical case)



power T/F ; $V = 4.44 f \varphi_m N$

$\downarrow \frac{V}{f} \propto \varphi \uparrow$ → causes core saturation

For this → load frequency control

(v) **Faster fault identification** and **clearance of fault** in **minimum time**

— Fault Analysis

— Protection

(vi) Stable Generator has to be maintained

— Stability

(viii) **Flexible power transfer**

— Power cable

Panther – 132 KV
Zebra – 220 KV
Moose – 400 KV

— : Transmission line Parameters & Performance :—

By using transmission line, electric power is transfer from the remote generating station to the load centre (electric power utilised).

Material of Transmission line :-

ACSR – Aluminium conductor steel Reinforced

Steel is used at the centre because it has higher mechanical strength to withstand and carry large weight of ACSR conductor.

4 layer ACSR (37 - 30/7)

strands ← Al, steel

5 layer ACSR (61 - 54/7)

strands ← Al, steel

No. of strands : $N = (3x^2 - 3x + 1)$

Total Dia $D = (2x-1)d$

x = layer number

d = Dia of each strands

Technical name of ACSR :- Animal like, Zebra, Panther, Moose, Dog etc is used for Alumnium for european standard and bird name like Swan, Sparrow, Raven, Pigeon etc is used as for US standard.

Power carrying capacities at 65°C :-

At 132 KV with 'Panther' ACSR = 75 MVA

At 220 KV with 'Zebra' ACSR = 200 MVA

At 400 KV with 'Moose' ACSR = 500 MVA .

$$3\phi \text{ T/L} \Rightarrow \sqrt{3}\, V \cdot I \cos\phi = P_{3\phi}$$

$$\sqrt{3} \times 400 \times 10^3 \times I \times 0.95 = 500 \times 10^6$$

$$I = 759.67 \text{ A} \quad \text{carrying current by Moose}$$

Tower configuration :-

3 bundle conductor not practically used due to mechanical strength.

Classification of Transmission line :-

(i) Short line – $l < 80$ km, $lf < 4000$

(ii) Medium line – $80 \le l \le 200$ km, $4000 \le lf \le 1000$

(iii) Long line – $l > 200$ km, $lf > 1000$

where l = length of Tx. line f = supply frequency = 50Hz

Ex-: Short line $lxf = 80 \times 50 = 4000$

NOTE-: communication line operating at MHz range hence considered as long transmission line because $lf > 10{,}000$ for any length of line

Q.N:- A T/L is excited by the frequency of

(i) 300Hz (ii) 50Hz (iii) 600Hz

Find the type of T/L if its physical length is 20 km?

Solution :-

(i) 300Hz $lf = 20\text{km} \times 300\text{Hz} = 6000$ (lf).

↳ $4000 \le lf \le 1000 \rightarrow$ Medium

(ii) 50Hz $lf = 20\text{km} \times 50\text{Hz} = 1000 \longrightarrow$ short line ($lf < 4000$)

(iii) 600Hz $lf = 20\text{km} \times 600\text{Hz} = 12{,}000 \longrightarrow$ long line $lf > 10000$

Transmission line Parameters :-

(i) Inductance (L)

(ii) capacitance (C)

(iii) Resistance (R)

(iv) conductance (G)

Inductance :-

current ⟶ produce flux ⟶ link with other 2 phase also i.e; due to flux (self + Mutual) produces inductance in it.

capacitance :-

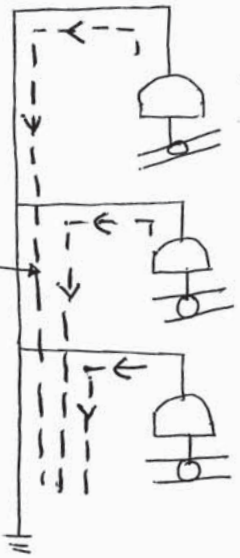
Two metal is separated by some distance & operating at some voltage produce capacitance in it & ground capacitance also exists.

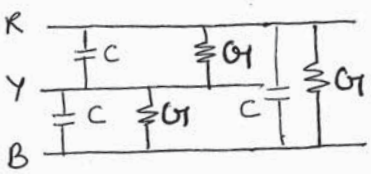
Resistance :-

ACSR has certain cross section area & length which will produce resistance.

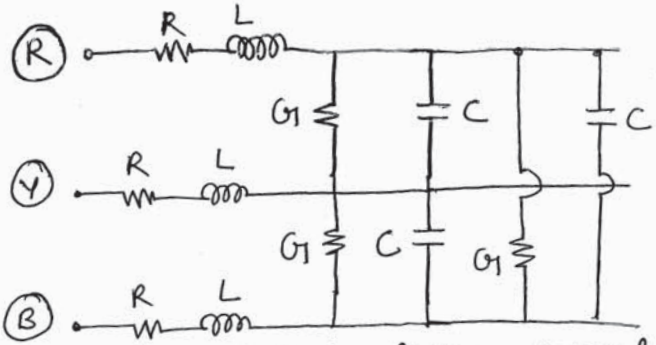
conductance (G) :- The leakage current flowing through the supporting insulator is represented by the conductance parameter. It's value is very small and hence neglected in case of short & medium line and consider in the long transmission.

Electrical equivalent of leakage current ⟹ conductance (G)





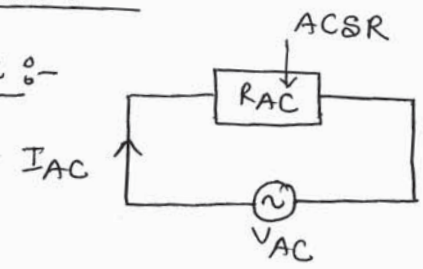
series element ⇒ R & L
shunt element ⇒ C & G



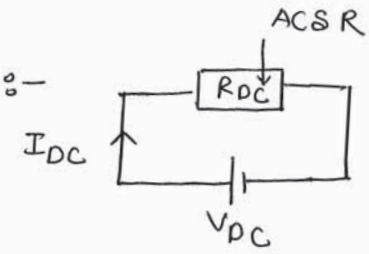
:- Electrical eq^{t} of x-mission line :-

Resistance :-

HVAC :-

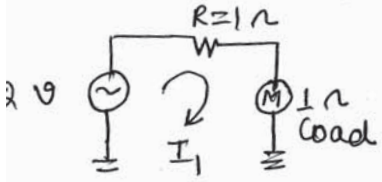


HVDC :-

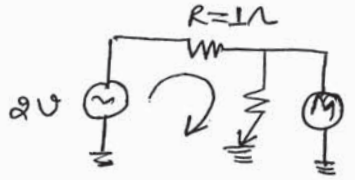


$R_{AC} > R_{DC}$ Due to (i) skin effect (ii) proximity effect

$R_{AC} = 1.5\, R_{DC}$



$I_1 = \frac{2}{1+1} = \frac{2}{2} = 1\,A$



$I_2 = \frac{2}{1} = 2\,A$

$I_2 = 2I_1$ during short ckt condition

Short ckt rating : KA/S [maximum current able to withstand during fa

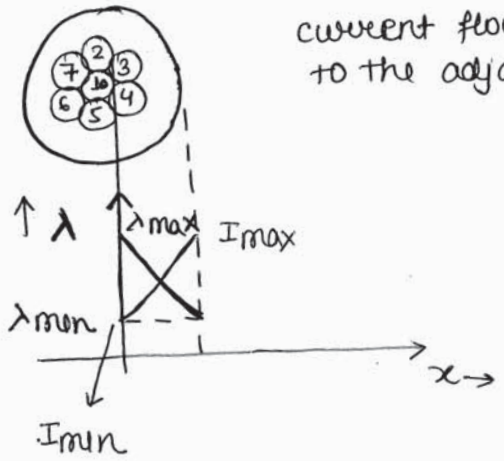
RTS : KN

(i) Skin effect :-

(a) Accumulation of the current on the surface of conductor is called skin effect

⊙ outwards current

current flowing in the conductor producing flux to the adjacent of conductor



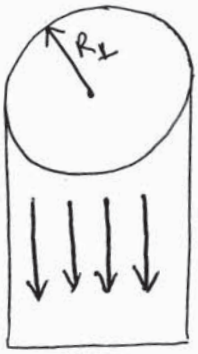
λ_{max} i.e; L_{max} then $X_L \uparrow$

$\downarrow I = \frac{V}{X_L \uparrow}$

λ_{min} i.e; L_{min} then $X_L \downarrow$

$\uparrow I = \frac{V}{X_L \downarrow}$

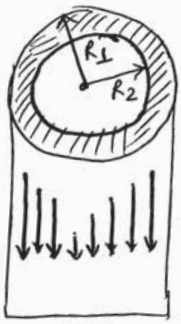
HVDC :



uniform current is flowing because there is no rate of change of flux.

$$R_{DC} = \frac{\rho l}{\pi R_1^2}$$

HVAC :



$$R_{AC} = \frac{\rho l}{\pi (R_1^2 - R_2^2)}$$

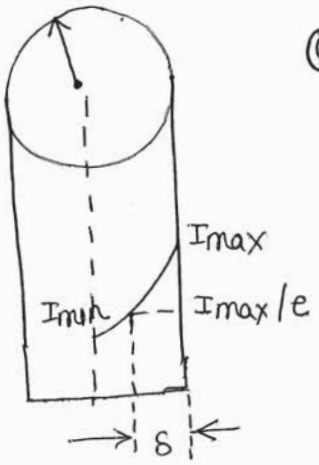
(b) Due to skin effect, effective area of current flowing path is reduced which causes $R_{AC} > R_{DC}$. in HVAC system.

(c) Skin effect depends on f, σ, μ_r and size of the conductor.

(d) Skin effect is more in communication line because frequency is in MHz range and this effect is neglected in power lines because the frequency is less (50Hz) only.

f = supply frequency, μ_r = Relative Permeability σ = conductivity

Skin depth (δ) :-



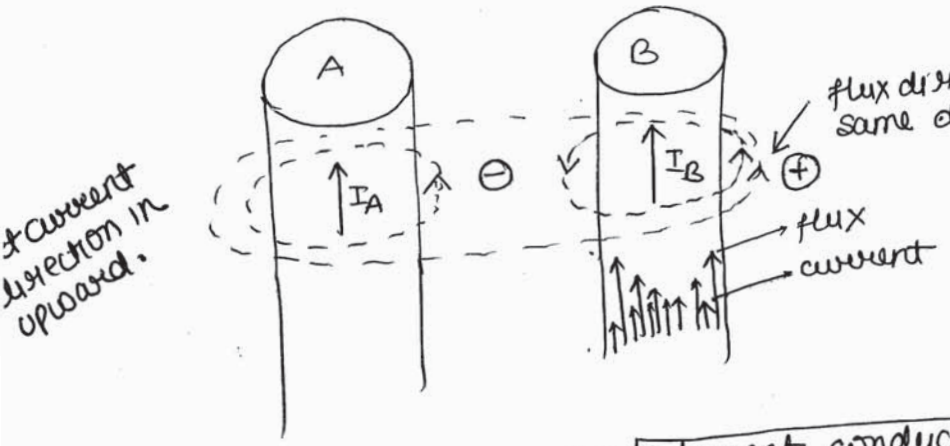
(a) The depth of the conductor at which the current is drop to (1/e) time of the maximum current & that depth is called as skin depth.

$$\delta = \frac{1}{\sqrt{\pi f \mu_0 \mu_r \sigma}} \propto \frac{1}{\text{skin effect}}$$

(b) when skin depth is less then more accumulation of current on the surface of conductor, then skin effect will be more

(c) In HVDC, no skin effect because $f = 0$

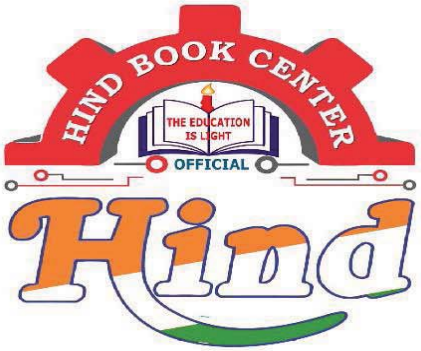
Proximity effect :-



(a) The current flowing in the adjacent conductors produces non-uniform flux linkage which will cause non-uniform current flow so, that the effective area of current flowing path is reduce which causes $R_{AC} > R_{DC}$ (we are not able to utilise whole area)

(b) Proximity effect depends on f, μ_r, σ & distance between the conductors

(c) This effect is more in power cable and less in overhead transmission line because .



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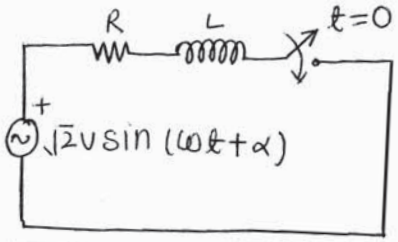
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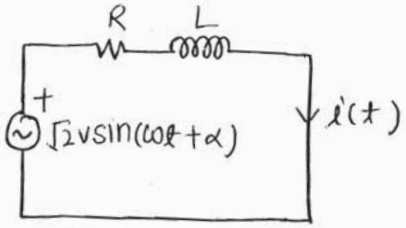
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Power Analysis of AC circuit :-

(i) A circuit which is in steady state corresponding to a given sinusoidal excitation is called an AC circuit.



$t \to \infty$ (SS)



Not an AC circuit

because it is in transient state

$\therefore i(t) = i_{SS} + i_{TR}$

i_{SS} = Steady state response depends upon the source

i_{TR} = Transient response depends upon the circuit itself

$i(t) = \sqrt{2}I\sin(\omega t+\beta) + Ae^{-t/\tau}$

$\therefore$ Responses are non-sinusoidal

An AC circuit

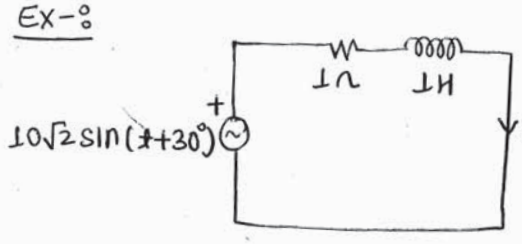
$i(t) = \sqrt{2}I\sin(\omega t+\beta)$

Responses are sinusoidal and having same freq.

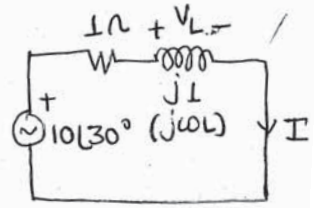
(ii) All the responses of an An ac circuit are sinusoidal with frequency equal to the source frequency.

(iii) The magnitude (RMS value) and phase of a response in an AC circ is computed using phasor technique

Ex-:



Phasor domain eqt ckt
ref. waveform
$= \sin t$



Reference waveform is selected such that frequency of ref. waveform should be equal to the frequency of source.

In phasor diagram equivalent ckt we have to take rms value.

$V_m = 10\sqrt{2} \Rightarrow V_{RMS} = 10$

	Time domain	Phasor domain	Frequency domain
Inductor	Henery (H)	jX or $j\omega L$	sL
Capacitor	Farad. (F)	$1/(j\omega C)$	$1/sC$
Resistance	R	R	R

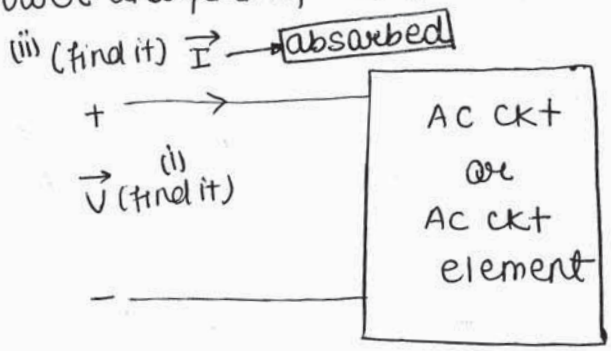
$$I(t) = \frac{10\angle 30^\circ}{1+j1} = \frac{10}{\sqrt{2}}\angle -15^\circ = 10\sin(t-15^\circ)$$

$\frac{10}{\sqrt{2}}$ → RMS value; $10\sin(t-15^\circ)$ → Maximum value

By applying voltage division rule

$$V_L = 10\angle 30^\circ \left(\frac{j1}{1+j1}\right) = \frac{10}{\sqrt{2}}\angle 75^\circ = 10\sin(t+75^\circ)$$

Now power analysis of an AC circuit



complex power absorbed by AC CKt or element

$S = \vec{V}\,\vec{I}^{*}$ [find it] (iii)

$= P + jQ$

(iv) Then;

P = Active power / useful power / Avg. power / power absorbed by AC CKt or AC CKt element (watt)

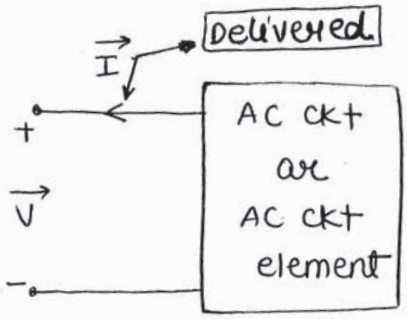
Q = Reactive power / lagging VAR absorbed by the AC CKt element or AC CKt. (VAR)

By default Active power

$P>0$ → CKt absorbed active power
$P<0$ → CKt delivers active power

$Q>0$ → CKt. absorbed Reactive power / lagging VAR or CKt delivers leading VAR

Q<0 → CKt delivers Reactive power / lagging VAr
or
CKt absorbs leading VAr.



complex power delivered by AC CKt or AC CKt element

$S = VI^* = P + jQ$

P = Active power / useful power / Average Power / Power delivered by AC ckt or AC ckt element

Q = Reactive power / lagging VAr delivered by the AC ckt element or AC ckt.

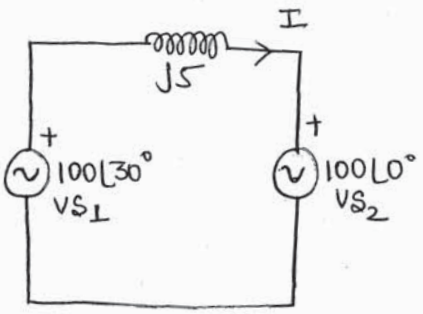
P > 0 = ckt delivers active power

P < 0 = ckt absorbs active power

Q > 0 = ckt. delivers Reactive power / lagging VAr
or
ckt absorbes leading VAr

Q < 0 = ckt. absorbs Reactive power / lagging VAr
or
ckt delivers leading VAr

EX-:



$$I = \frac{100\angle 30^\circ - 100\angle 0}{j5}$$

$$= 10.35\angle 15^\circ$$

complex power absorbs by VS-2

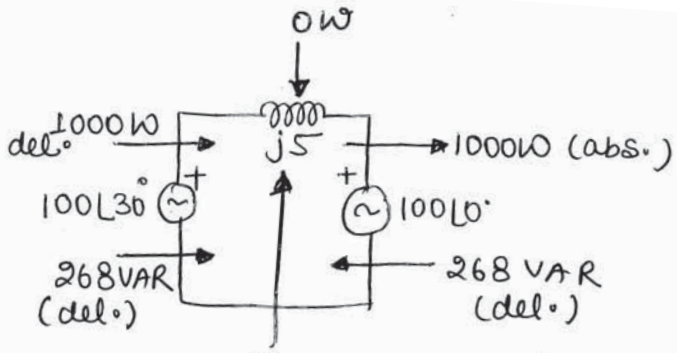
$$S = (100\angle 0^\circ)(10.35\angle 15^\circ)^* = 1000 - j268$$

VS_2 : absorbs 1000W and delivers 268 VAr

complex power delivered by VS-1

$$S = 100\angle 30^\circ)(10.35\angle 15^\circ)^* = 1000 + j268$$

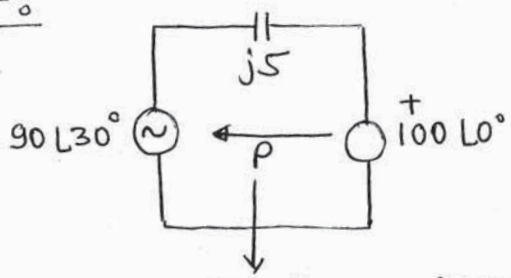
VS_1 : delivered 1000W and delivers 268 VAr

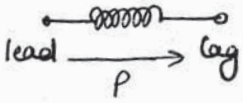


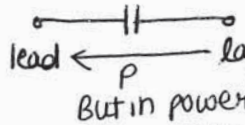
= 268VAR + 268 VAR & [Active power = 0 (always)]

NOTE-: In power system active power always flows from leading voltage source towards the lagging voltage source where as reactive power generally flow from voltage of high magnitude towards voltage of low magnitude.

EX-:



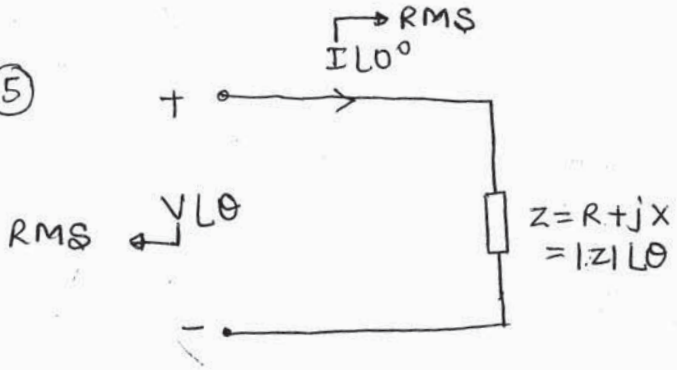




But in power system in series capacitor is not present i.e; not power system ckt.

i.e; flowing from lagging to leading voltage source because it is not power system ckt. b° the series branch of power system is always inductive in nature.

(5)



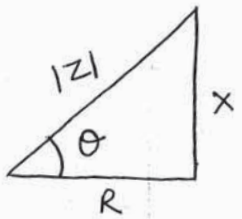
x = +ve ⟶ inductance
x = -ve ⟶ capacitance

$Y = \frac{1}{Z} = G + jB$

B = -ve ⟶ inductance
B = +ve ⟶ capacitance

$|Z| = \sqrt{R^2 + X^2}$

$\theta = \tan^{-1}\frac{X}{R}$



$\cos\theta = \frac{R}{|Z|}$

$\sin\theta = \frac{X}{|Z|}$

$\vec{V} = \vec{I}\,\vec{Z}$

$= I L0^\circ \; Z L\theta$

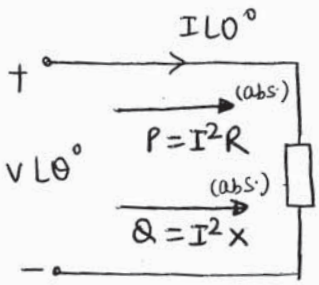
$= IZ L\theta = VL\theta$

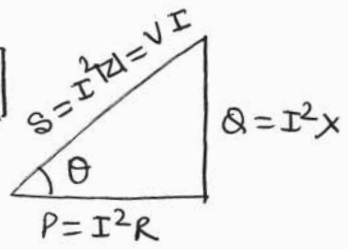
so, complex power absorbs by $Z = R + jX$

$$S = P + jQ = (V\angle\theta)(I\angle 0)^* = VI\cos\theta + jVI\sin\theta$$

$$P = VI\cos\theta = VI\frac{R}{|Z|} = I^2R$$ → RMS value

$$Q = VI\sin\theta = VI\cdot\frac{X}{|Z|} = I^2X$$ → RMS value





∴ power triangle

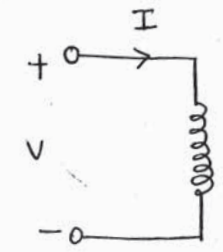
$$p.f. = \cos\theta = \frac{P}{S}$$

$R \geq 0 \longrightarrow P \geq 0$ so, $Z = R + jX$ can't deliver active power.

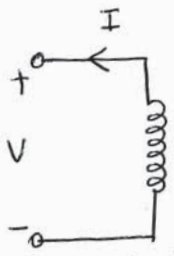
$X > 0$ (inductive) → $Q > 0$ i.e, inductive Impedance absorbs Reactive power / lagging VAR
(or) inductive Impedance delivers leading VAR

$X = 0$ (Resistive) → $Q = 0$

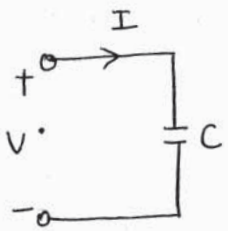
$X < 0$ (capacitive) → $Q < 0$ i.e, capacitive impedance delivers Reactive power / lagging VAR
(or)
capacitive Impedance absorbs leading VAR



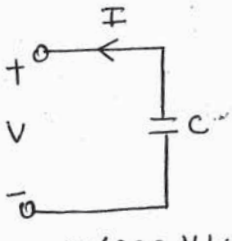
I laggs V by 90°



I leads V by 90°



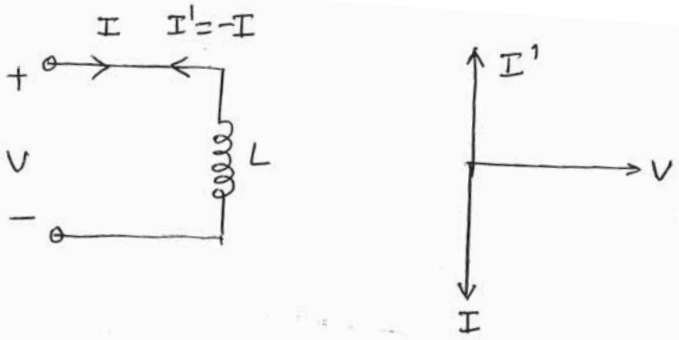
I leads V by 90°



I lags V by 90°

(By default we take absorb current always)

Ex-:



For I (अन्दर को आने वाली) current is lagging then it always absorbs lagging VAR.

For I' which is leads by V then it always delivers leading VAR.

NOTE-:

(i) overexcited synchronous M/C → requirement of flux get excess in m/c then it will deliver reactive power

→ delivers reactive power / lagging VAR i.e; lagging current
(or)
absorbs leading VAR i.e; leading current [Always]

(ii) underexcited synchronous M/C

[Always] →

absorbs reactive power / lagging VAR i.e; lagging current
(or)
delivers leading VAR i.e; leading current

Now; Motor → absorb the current & current may be leading or lagging in nature

Generator → delivers the current & current may be leading or lagging in nature

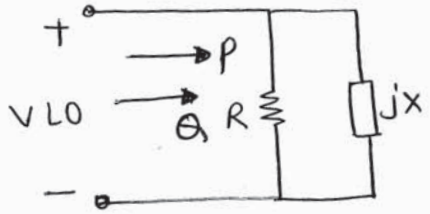
Overexcited syn. motor → motor absorbs the current i.e; absorbs leading VAR

we can say that Pf ≡ leading

Over excited Sync. Generator → Generator delivers the current i.e; delivered lagging VAR i.e lagging current

we can say that p.f ≡ lagging

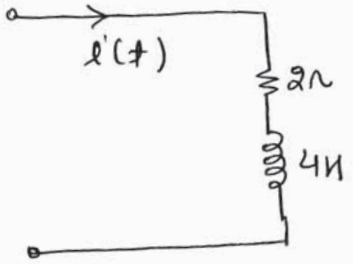
#



$P = \frac{V^2}{R}$ → RMS value

$Q = \frac{V^2}{X}$ → RMS value

Ex-:



$i(t) = 10\sin(\overset{\omega}{2}t + 30°)$

P = ? Q = ?

$P = I^2R = \left(\frac{10}{\sqrt{2}}\right)^2 \times 2 = 100\,W$ [$X = \omega L$]

$\omega = 2,\ L = 4$

$Q = I^2X = \left(\frac{10}{\sqrt{2}}\right)^2 \times (2\times 4) = 400\ VAR$

I = RMS value

Balance 3-φ system / concept of phase sequence :-

A polyphase system is said to be balance if

(i) The magnitude of corresponding quantity are equal in each phase.

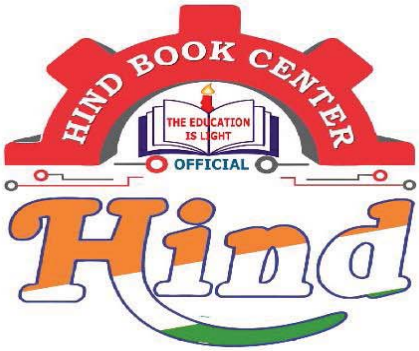
(ii) The phase difference b/w the corresponding quantities is given by

$\theta = \frac{360°}{n}$; $n \neq 2$
$\theta = 90°$; $n = 2$

Q.N:- The current in 2-phases of a two phase system is given below

$i_a = \sqrt{2}\,I\cos(\omega t - \varphi_1)$ $i_b = \sqrt{2}\,I\sin(\omega t - \varphi_2)$

Find the relationship b/w φ_1 and φ_2 so that the two phase system is balance system.



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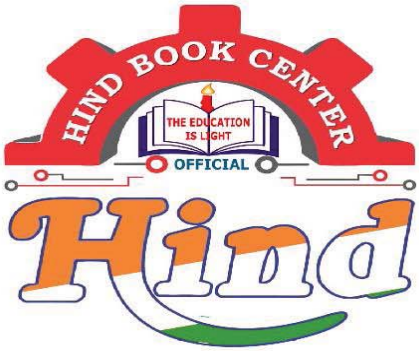
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—: Induction machine :—

Due to complex construction, commutation problems, maintenance DC m/c find lesser practical applications.

while AC motors has simplex construction, less maintenance hence these are most popular (85% motors)

(i) Induction generator

(ii) Induction motor

Rotating Magnetic field (RMF) :—

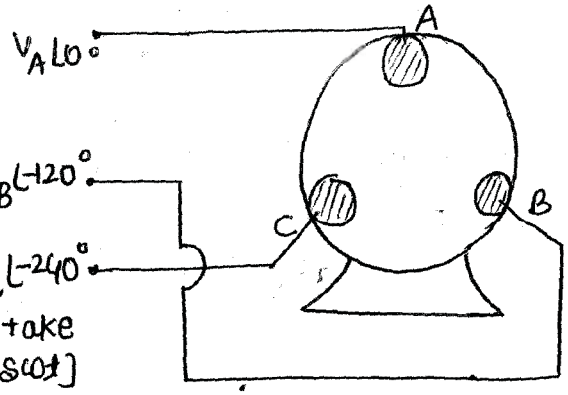
In I/M, the **flux** is **not stationary**, it is **rotating**.

The **basic requirement** to **produce** the **rotating magnetic field** is

(i) **3φ supply** (**120° E** phase displacement **w.r.t. time**)

(ii) **3φ winding** (**120° E** phase displacement **w.r.t. space**) } Balance

If we want to generate 3-ph voltages which has 120° E phase displacement we have to design a winding which has exactly 120° E space displacement, the space displacement which we provide in the winding will create time displacement in the voltages which are induced.



Balance winding i.e; Number of turns are equal in all the winding.

Balance supply i.e; $|V_A|=|V_B|=|V_C|$ & 120° E displacement

$mmf = NI$

$V_A L0°$	$\longrightarrow I_A N_A$	$\longrightarrow \vec{F_A}$	$\longrightarrow \vec{\varphi_A}$
$V_B L-120°$	$\longrightarrow I_B N_B$	$\longrightarrow \vec{F_B}$	$\longrightarrow \vec{\varphi_B}$
$V_C L-240°$	$\longrightarrow I_C N_C$	$\longrightarrow \vec{F_C}$	$\longrightarrow \vec{\varphi_C}$

Net mmf produce $= \vec{F_A} + \vec{F_B} + \vec{F_C}$

Net flux produce $= \vec{\varphi_A} + \vec{\varphi_B} + \vec{\varphi_C}$

Now,

$I_A = I_m \cos\omega t$ $\qquad$ $N_A = N\cos\theta$

$I_B = I_m \cos(\omega t - 120°)$ $\qquad$ $N_B = N\cos(\theta - 120°)$

$I_C = I_m \cos(\omega t - 240°)$ $\qquad$ $N_C = N\cos(\theta - 240°)$

where ωt = time displacement angle (ele.)

θ = space displacement angle (ele.)

$$F_A = I_A N_A = I_m \cos\omega t \cdot N \cos\theta$$

$$F_B = I_B N_B = I_m \cos(\omega t - 120^\circ) \cdot N \cos(\theta - 120^\circ)$$

$$F_C = I_C N_C = I_m \cos(\omega t - 240^\circ)\, N \cos(\theta - 240^\circ)$$

$$\cos A \cdot \cos B = \frac{1}{2}[\cos(A+B) + \cos(A-B)]$$

Net / Resultant mmf $F_{net} = F_A + F_B + F_C$

$$F_{net} = I_m N [\cos\omega t \cdot \cos\theta + \cos(\omega t - 120^\circ) \cdot \cos(\theta - 120^\circ) + \cos(\omega t - 240^\circ) \cdot \cos(\theta - 240^\circ)]$$

$$= I_m N \left[\frac{1}{2}\{\cos(\omega t + \theta) + \cos(\omega t - \theta)\} + \frac{1}{2}\{\cos(\omega t - 240^\circ + \theta - 120^\circ) + \cos(\omega t - 120^\circ - \theta + 120^\circ)\} + \frac{1}{2}\{\cos(\omega t - 240^\circ + \theta - 240^\circ) + \cos(\omega t - 240^\circ - \theta + 240^\circ)\}\right]$$

$$= \frac{I_m N}{2}\left[\cos(\omega t + \theta) + \cos(\omega t - \theta) + \cos(\omega t + \theta - 240^\circ) + \cos(\omega t - \theta) + \cos(\omega t + \theta - 480^\circ) + \cos(\omega t - \theta)\right] \quad [* + * + * = 0]$$

$$F_{net} = \frac{I_m N}{2}[3\cos(\omega t - \theta)]$$

$$\boxed{f_{net} = \frac{3}{2} I_m N \cos(\theta - \omega t)} \quad \text{(or)} \quad \boxed{F_{net} = \frac{3}{2} F_m \cos(\theta - \omega t)}$$

i.e; The net mmf wave is cosine or sine, it is travelling w.r.t. space & time both so; it is function of space angle and time angle. If we don't have the two combination which are 3-φ supply (120° E phase displacement) and 3-ph windg (120° E phase displacement w.r.t space) then mmf wave don't came like this.

$$\text{speed} = \frac{\text{Distance}}{\text{Time}}$$

Imagine mmf wave has some velocity or speed and displacement ωt.

$$\boxed{\text{speed} = \frac{\omega t}{t} = \omega \text{ Elect-rad/sec}}$$

$N = rpm$ | $N/60 = rps$ | $\omega = 2\pi f$ elet-rad/sec

$\omega_m = \frac{2\pi N}{60}$ mech-rad/sec

$\theta_e = \frac{P}{2}\theta_m$

similarly, $\omega_e = \frac{P}{2}\omega_m \Rightarrow 2\pi f = \frac{P}{2} \cdot \frac{2\pi N}{60}$

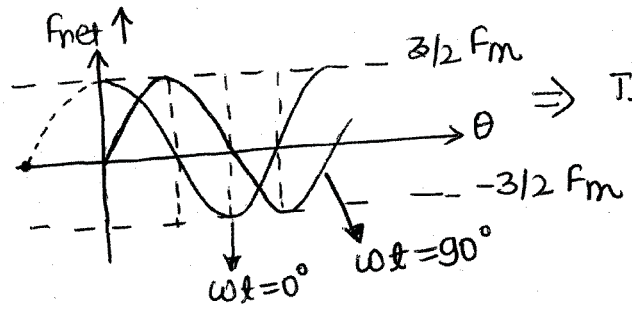
$f = \frac{PN}{120}$

so, $N = \frac{120f}{P}$

we know that $f_{net} = \frac{3}{2} F_m \cos(\theta - \omega t)$

let $\omega t = 0$ then $f_{net} = \frac{3}{2} f_m \cos\theta$

let $\omega t = 90°$ then $f_{net} = \frac{3}{2} f_m \sin\theta$



$\Rightarrow$ Travelling or moving with constant amplitude w.r.t space

If

$I_A = I_m \cos\omega t$

$I_B = I_m \cos(\omega t)$

$I_C = I_m \cos(\omega t)$

$N_A = N\cos\theta$

$N_B = N\cos(\theta - 120°)$

$N_C = N\cos(\theta - 240°)$

Then $f_{net} = 0$ if voltage and current are co-phasor.

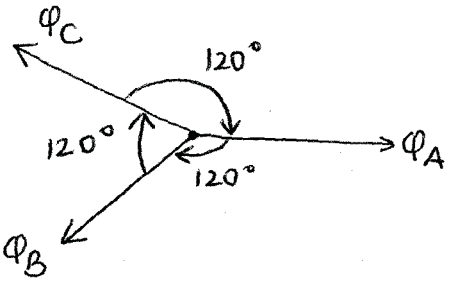
NOTE:- By reversing the phase sequence the direction of movement of mmf is also reverse.

Another approach :-

$\phi_A = \phi_m \sin\omega t$

$\phi_B = \phi_m \sin(\omega t - 120°)$

$\phi_C = \phi_m \sin(\omega t - 240°)$

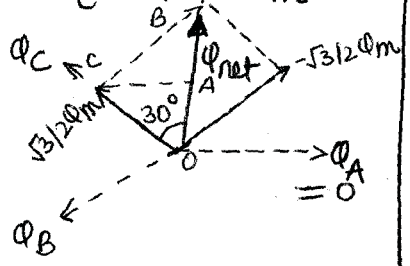


At $\omega t = 0°$

$\phi_A = 0$

$\phi_B = -\sqrt{3}/2\,\phi_m$

$\phi_C = \sqrt{3}/2\,\phi_m$



$OB = 2OA$, $\angle AOC = 30°$

From ΔOAC

$\cos 30° = \frac{OA}{OC}$

$OA = OC\cos 30°$

$= \frac{\sqrt{3}}{2}\phi_m \cdot \frac{\sqrt{3}}{2}$

$OA = \frac{3}{4}\phi_m$

$OB = \phi_{net} = 2OA$

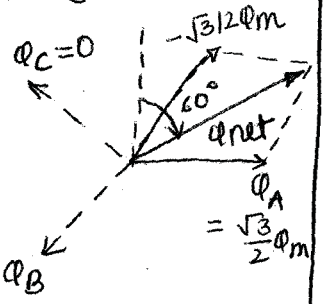
$\boxed{\phi_{net} = \frac{3}{2}\phi_m}$

At $\omega t = 60°$

$\phi_A = \sqrt{3}/2\,\phi_m$

$\phi_B = -\sqrt{3}/2\,\phi_m$

$\phi_C = 0$



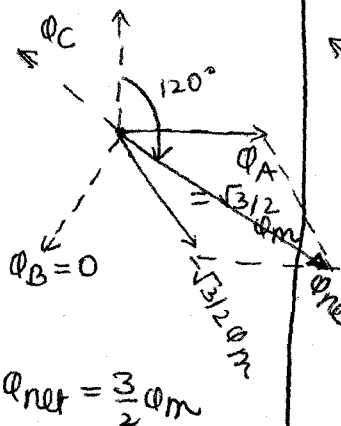
$\phi_{net} = \frac{3}{2}\phi_m$

At $\omega t = 120°$

$\phi_A = \sqrt{3}/2\,\phi_m$

$\phi_B = 0$

$\phi_C = -\sqrt{3}/2\,\phi_m$



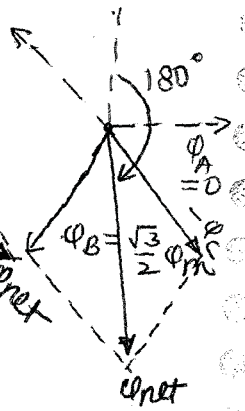
$\phi_{net} = \frac{3}{2}\phi_m$

At $\omega t = 180°$

$\phi_A = 0$

$\phi_B = \sqrt{3}/2\,\phi_m$

$\phi_C = -\sqrt{3}/2\,\phi_m$



$\phi_{net} = \frac{3}{2}\phi_m$

Synchronous

↓

i.e; time (moving together with time)

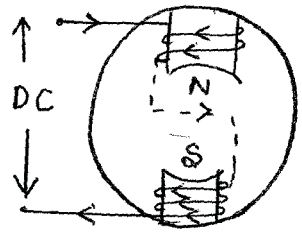
when flux rotate in the m/c then that flux speed will be synchronous speed. It depends on two factor which are frequency and number of pole.

$\phi_{net} = \frac{3}{2}\phi_m$ $\qquad \boxed{N_S = \frac{120f}{P}}$

Characteristics of RMF :-

(i) RMF has constant value ($1.5\phi_m$)

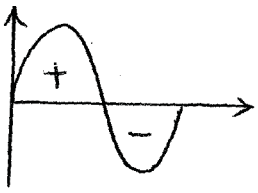
(ii) RMF revolves with $N_s = 120f/p$



[To know North pole or south pole we have to apply right hand grip rule.]

If we reverse the polarity of battery then current direction gets change then N ⟶ S and S ⟶ N. So, when reversal action is not happening then DC supply is having $f = 0$ due to which pole is not going to change in any manner.

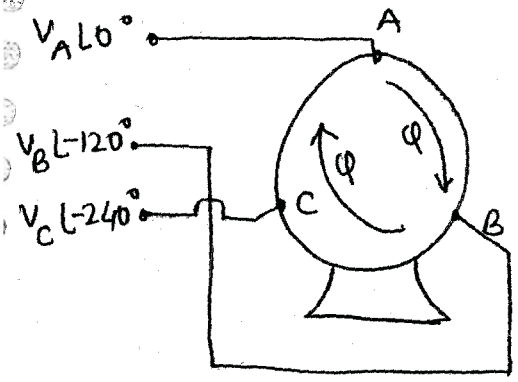
When we talking about AC supply with $f = 1Hz$ i.e, 1 cycle in 1 sec

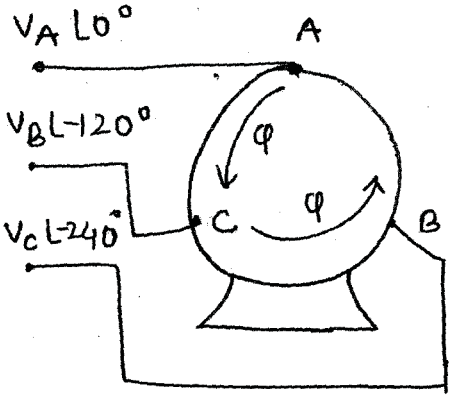


So in +ve cycle the polarity of pole is same as before but in -ve cycle N ⟶ S & S ⟶ N. (or) North at top ⟶ bottom, South at bottom ⟶ top

$$N_s \propto \frac{1}{p}$$

(iii) RMF flows from leading phase to lagging phase. Its direction of rotation can be reversed by reversing any two phase sequence of supply.





Construction details of Induction machine :-

(i) Stator
- → Frame
- → core
- → 3-ph winding

⇓ **Stationary part**

(ii) Rotor
- → squirrel cage
- → slip ring or wound rotor

⇓ **Rotating Part**

(iii) Air gap
- → **least possible**

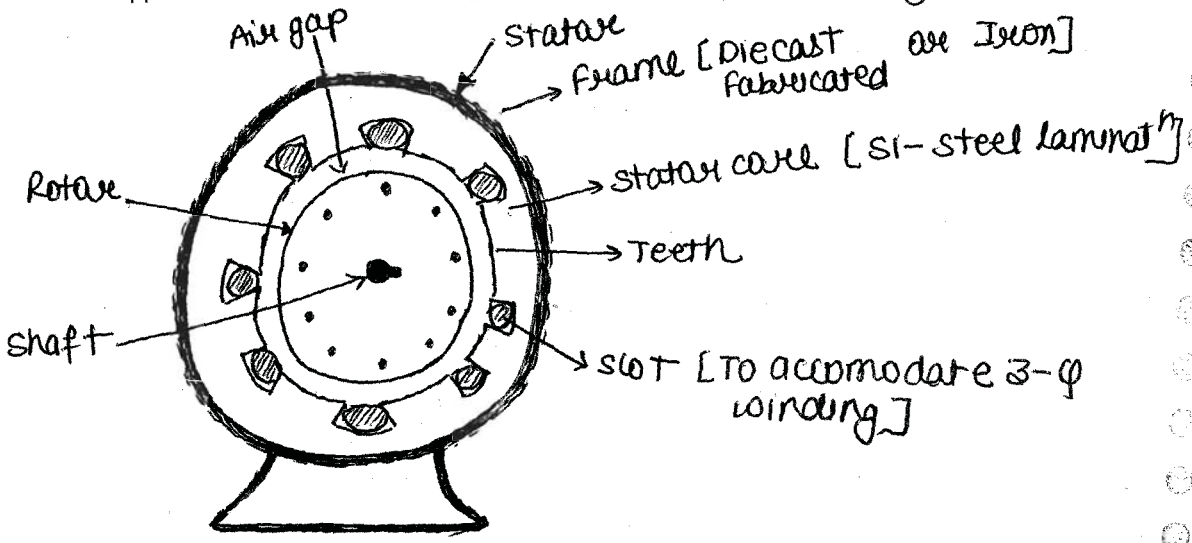
$$\text{Flux} = \frac{\text{mmf}}{\text{Reluctance}}$$

(0.3mm to 4mm)

Frame :- Frame offer **mechanical protection** to the m/c.

core :- core is **laminated structure** [Si-steel lamin 0.35-0.5 mm thickness]

Slot :- slot offer **mechanical protection** to the **winding**.



Type of slots :

(i) open slot (ii) closed slot (iii) semi-open / semi closed slot

NOTE-: In **slot**, there is **small inclination** to **avoide creeping** of **armature winding** i.e, due to mechanical vibration the winding which is placed in slot may come out. that process is known as creeping.



NOTE-: Sometime in slot, **wedge** is also form because **after** placing **the winding in slot**, some **strip is to placed** so that they are **supporting it** [compulsary in rotating m/c]



NOTE-: In rotating electrical m/c we never see CRCN core type of structure because in this flux is rotating in air gap also. so, Si-steel lamination is enough for it.

To make flux as maximum as possible for that we have to maintain Reluctance to be minimum as much as possible the for this we have to maintain least possible air gap. (0.3mm to 4mm)

In small m/c : Air gap = 0.3mm
large m/c : Air gap = 1mm

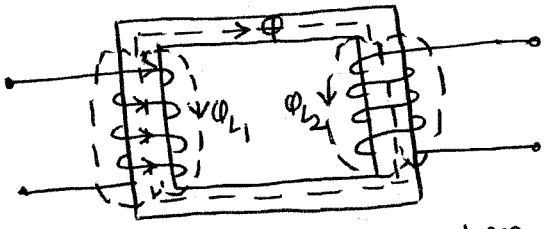
Air gap ↑ → Im ↑
↳ Drawback

NOTE-: Yoke & frame both are different to each other. In D/C machine the flux is passing through yoke only

⇒ Casting is process considering molten metal on moulding it gets its shape. & Fabrication is solid metal only.

(i) open slot :-

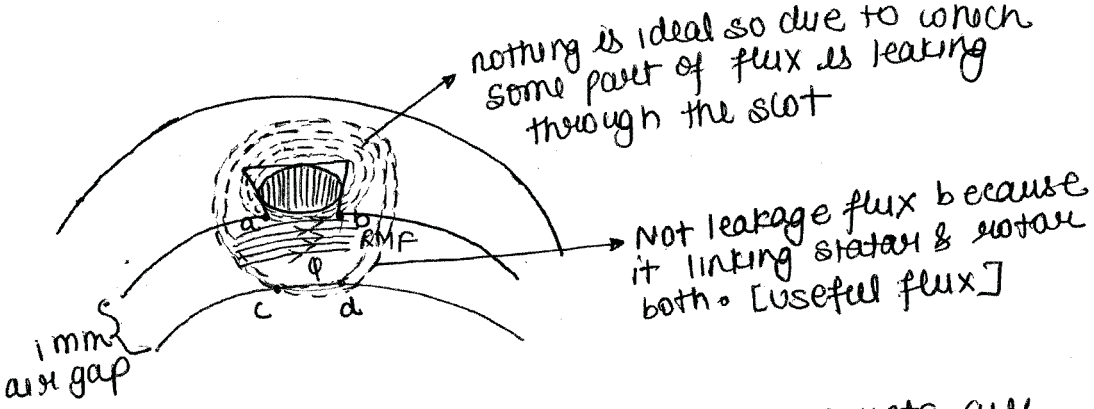
(a) Easy to place the winding in slot
(b) During maintenance, repair or routine service, it is so easy.
(c) simple design
(d) leakage flux :



⇒ If flux is linking with two winding then it is useful flux because it is transfering the energy

⇒ If flux is linking & leaking with only one winding then it is not participating in the transfering the energy. [wasted]

Link	Leak
—: Reluctance	—: Reactance
more Airgap then Reluctance will be higher.	more leakage of flux then Reactance will be also more



The gap between a and b is not air gap but it accounts air gap. but the air gap will be between stator and rotor. The air gap between a and b is within the stator. so, air gap is radial length between a & c, b & d.

But during resultant/net air gap, the gap between a & b will be consider.

leakage path is between a to b. when we reduce the air gap i.e; 1mm → 0.5mm then maximum no. of line in comparision with before become linkage flux because while leaking the flux it gets link.

so, lesser the air gap we have excellent flux linkage i.e; more useful flux. & vice-versa.

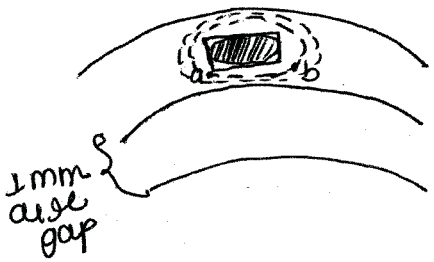
Imagine rotor are touching the stator then leakage flux will be minimum. But rotor will not rotate. so, we need mechanical clearance between stator and rotor part. So we maintaine as much as last possible.

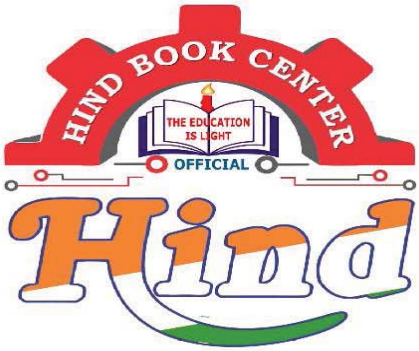
Between a & b, air gap is exists & we know that air gap offer reluctance to the flux [leakage]

Reluctance ↑ → flux ↓ [leakage] then leakage reactance ↓ & lagging p.f will also ↑ then p.f ↓.

In closed slot type between a & b, Si-steel is exists, which offering high permeability. so it encourage the leakage so, leakage flux will be higher through the stator. & leakage reactance will be higher due to this lagging p.f. (angle) will be less.

then p.f ↑.





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SYNCHRONOUS MACHINES

Gen Motor Condenser
M-G E-M ↑p.f

Gen Motor condenser
M→E E-M ↑p.f

- Commonly used generator in Power Plants universally, also called as alternator as it generates dc voltage which is steped up to much higher value and transmitted through x-mer.
- They run as a standard speed called as Synchronous speed for given freq and No of poles
- These are doubly excited type because rotor is excited by dc supply as well as additional mechanical i/p is given across the rotor
- Principle of Operation is according to Faradays Law.
- If a commutator is droped from a dc generator and if two slip rings are used to collect it is ac generator if it is rotated at Synchronous speed it can be called as synchronous generator but with rotating armature and stationary field structures.
- In DC generator winding (armature should rotate) for commutator action
  In alternators there is no such commutator therefore it is not necessary that the armature should be a rotating member; it can be either rotating or stationary.
- Small rating alternators < 5KVA only may have rotating armature but practically synchronous generators of large rating commonly contain

stationary armature rotating field structure.

Advantages of Stationary Armature:-

Eg 500 MVA
11 kV

$$I = \frac{500 \times 10^6}{\sqrt{3} \times 11 \times 10^3} = 26243 \text{ A}$$

* Excit Voltage is DC
125 – 500 V DC

1 MW power $I = \frac{1000000}{500} = 2000 \text{ A}$

1) Simple Design:- To collect large current from rotating part, becomes very complicated practically and expensive because (3+1) slip ring with H.V insulation and higher current carrying capacity. (3 Electrical + 1 Neutral)

2) Insulation is effective if armature is on stationary part: Stationary slots will offer better insulation as well as they offer more space

3) Efficient Cooling: It is easy to provide air passage, cooling tubes, water/hydrogen cooling on a stationary part.

4) More o/p: As the rotor is lighter in weight supports high speeds So for a given size it gives more o/p with more speed

5) Right Construction:- As the winding is on stationary part it has more dynamic balance against electromagnetic stresses during S.C

Due to more width of slot and teeth they are stronger.

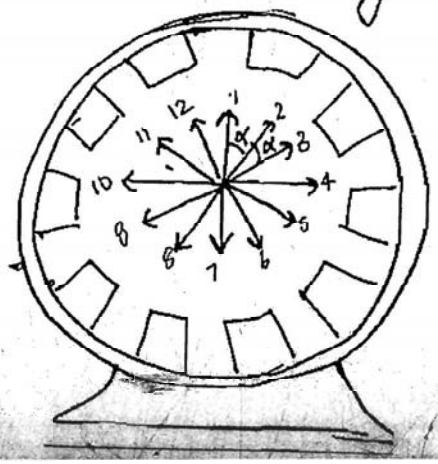
6) Leakage Reactance:- will be less because stator offers more width in the slots and contains more cu per slot. If it is on rotor depth will be high due to less space which produces more leakage reactance

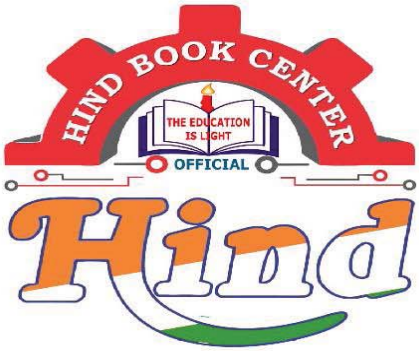
CONSTRUCTION DETAILS:-

- Like all other rotating electric machines it contain stationery part Stator, Rotating part Rotor with an air gap.
- The stator basically contain core and windings, rotor contains poles and field winding.

STATOR:-

- It contains an outer frame made up of cast iron or steel only for mechanical protection of the entire m/c there is a stator core made up of sheet steel (Si steel of 0.5mm thickness) to produce least core losses.
- The stator core is punched into slots which are generally open type in practical synchronous m/c, they contain 3-ϕ winding.





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—: TRANSFORMERS :—

Definition :

(i) Transformer is a **static device** which transfer AC electrical energy from one circuit to the another through the action of magnetic field.

Key word :

Transfer AC electric energy - through magnetic field

circuit is generalised word for coil and winding.

A magnet is surrounded by magnetic field called flux. Flux is a life of a machine whether you take DC M/C, Induction M/C, synchronous M/C, transformer, these all are working on the flux only. So **a machine work because of flux only.**

All the electricity we get is through flux only.

A generator works because of flux & a motor rotates because of flux, a **transformer transfer the power because of flux only.**

(ii) Transformer operate on the **principle of mutual induction**. b/w two or more magnetically coupled coils.

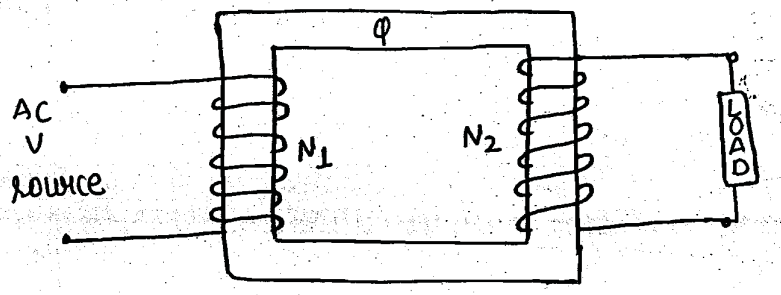
Key word :- Mutual induction principle b/w two or more magnetically coupled circuits (coil / winding)

(iii) It transform AC electrical energy or power at one voltage level to another voltage level **without the change in frequency & power**

Key word : - Transfer Electrical energy at one voltage level to another (at same F & P)

constant power means that the transformer have highest possible η in all electrical machinery / devices. Efficiency is almost 100% or in a well design transformer efficiency is close to 100% i.e; i/p power is equal to o/p power, the losses are very small & they can be neglected.

(iv) Magnetically coupled coils wound on common ferromagnetic core.



the connection b/w these two coils is due to the common flux. In the common core. i.e; these two coils are magnetically coupled when we connect the AC power source then there will be flux in transformer. then it produce voltage in another side

→ The coil which is connected to the source is called i/p winding or primary winding.

→ the other winding where is load connected is called secondary or o/p winding.

→ If transformer having third winding then it is called as tertiary winding.

→ one winding receive the power another one is delivering the power.

10 Aspects of transformer :

(i) static device i.e; No moving or rotating part, every thing is stationary

Flux : stationary

conductor : stationary

(ii) Electromagnetic energy conversion device (Internally)

i.e; externally no energy conversion is occurs

i/p is electrical ⟶ o/p is electrical

Internally operation ⇒ Electrical ⟶ Magnetic field ⟶ Electrical

NOTE-: Transformer is not a electrical machine. It is a device But we take like as a machine only.

Machine is a electromechanical energy conversion device.

i.e; Electrical ⇌ Mechanical

(iii) It is singly Excited device i.e; we applied voltage to only one winding of a transformer.

(iv) constant flux device neglecting the transient change in flux.

(v) constant powere

(vi) constant frequency

(vii) Magnetically coupled circuits [-ve magnetic coupling in accordance to lenz's law]

(viii) It is automatic control system [with negative feedback]

(ix) It is Phase shifting Device [w.r.t. voltage]

(x) It works only on AC

Classification of transformer :-

1. Based on No. of windings :

If there is 1 winding → Auto T/F

2 windings (primary & secondary)

3 windings (primary & secondary, tertiary)

2. Based on core construction :

(a) core type transformer

(b) Shell type transformer

3. Based on No. of phases :

(a) 1-φ T/F

(b) 3-φ T/F

Three 1-φ T/F are internally connected to 3-φ T/F bank.

4. Based on the operating frequency

(a) Power frequency T/F (25-500 Hz)

(b) Audio frequency T/F (20Hz to 20KHz)

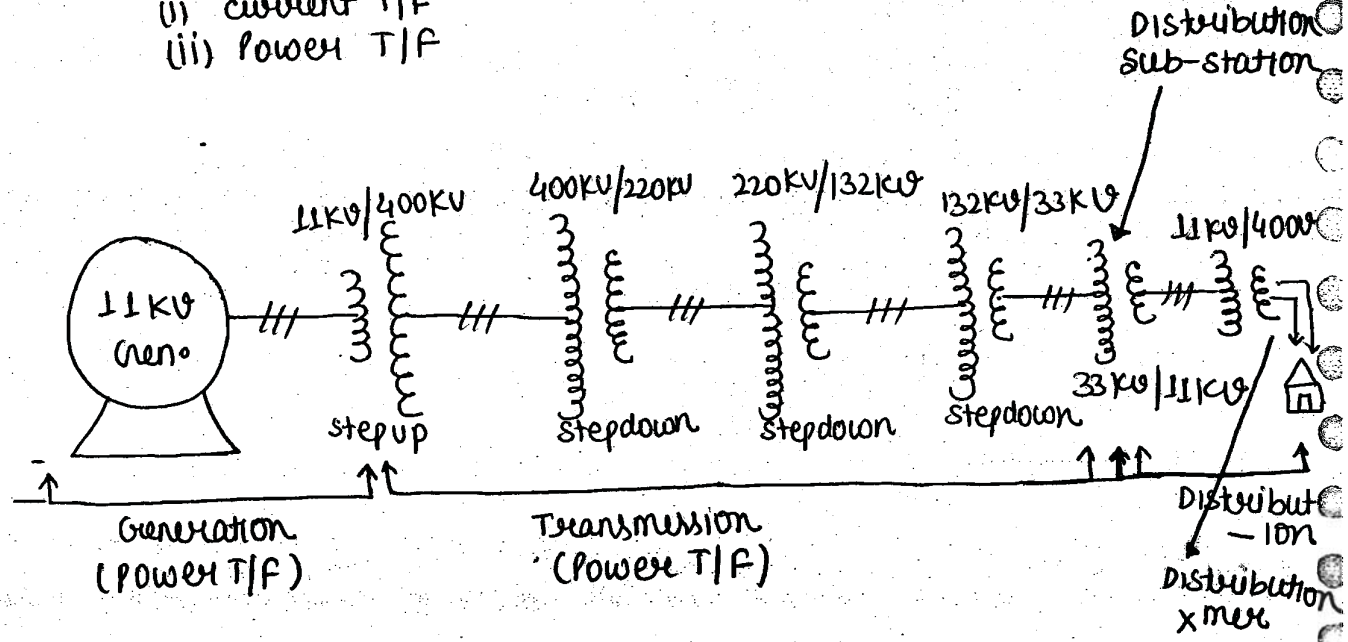
5. Based on Application : Many Numerous kind of T/F

(*) (a) Power system...
(i) Power T/F
(ii) Distribution T/F

(b) Power electronic
(i) Pulse T/F
(ii) Gate pulse triggering

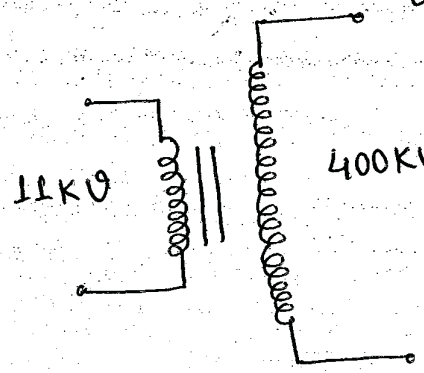
(c) Instrumentation
(i) current T/F
(ii) Power T/F

(d) Electronic & control system



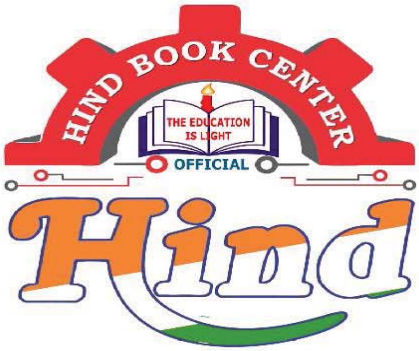
NOTE-:

Step up ⟷ Step down T/F can be used as



Step up mode : 11KV called primary winding.
400KV called secondary winding.

Step down mode : 11 KV called secondary winding
400 KV called primary winding.



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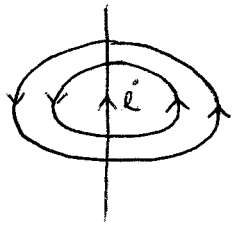
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CHRISTIAN OERSTED 1820 Electro magnetism :-

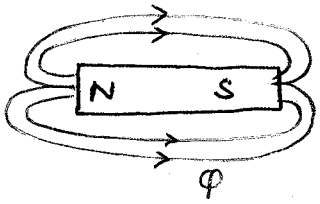
Relation b/w Electricity and magnetism

There is magnetic field around a current carrying conductor



current carrying conductor producing concentric flux line [Right hand Thumb rule] By using R-H thump rule fingure represent flux line direction and thumb in the current direction.

Every electrical machine is working because of flux.(φ) unit-weber



MICHAEL FARADAY (Father of Electricity) 1831 Electro Magnetic Induction :-

If current produce flux then why can't flux produce current?

NIKOLA TESLA 1880 RMF :- Rotating magnetic field

Induction & Synchronous machine is working on the bases of RMF

NIKOLA TESLA is behind AC power system.

ISSAC NEWTON 1687 Law's of motion

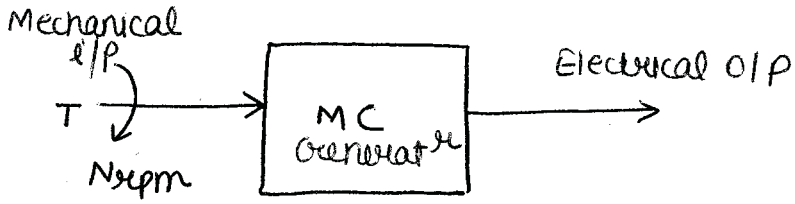
3rd law : Action ⟶ opposite reaction Len'z law -

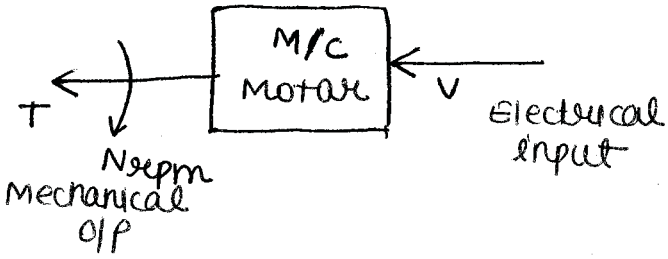
The result always the opposes the cause of it.

-: DC machine :-

Electrical Machine :-

Electro-Mechanical Energy conversion device

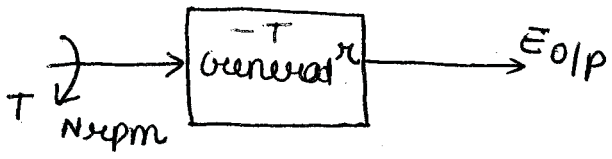




Electro mechanical : Reversible process [Pump storage Plant]

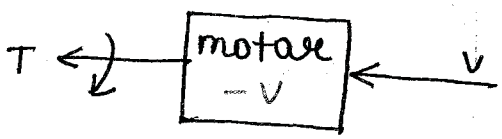
To maintaine the load factor, under light load condition acting like motor as well as making the water go back for ready the dam for peak load condition acting as generator.

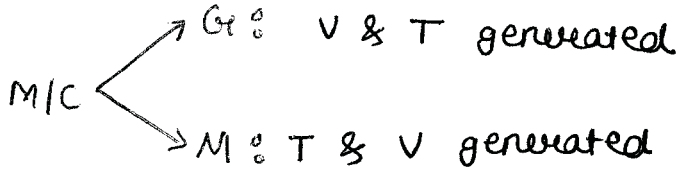
Generator :-
we are supplying torque then generator is rotating in one direction, when the generator is giving electrical o/p then in the generator another torque is produce. so in the generator voltage is produced as well as torque is also produce this torque which is produce in generator is exactly oppose the torque what we are giving.



'-' sign denotes the opposite direction

Motor :- when m/c is working as motor, we are giving some voltage then in m/c another voltage is developed which is exactly opposite to supply voltage.





Energy is never generated, so, Generator can't generate any by itself unless we rotate the generator

When a m/c is acting like generator mode or motor mode two things are commonly happen (V & I) that's why DC machi can be used as motor as well as Generator

Transformer is not a electrical machine because there is no electro-mechanical Energy conversion happens in it. In transfor mer electro-magnetic conversion takes place. internally.

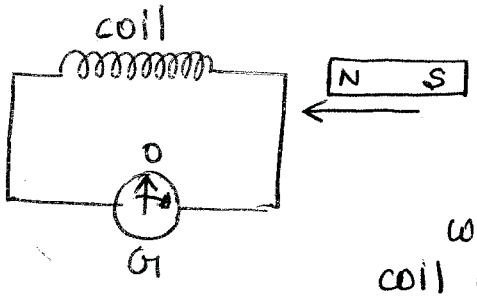
DC Generator :-

construction details of DC Generator is exactly similar to DC motor, difference in characteristic and application.

DC Generator, is Rotating electrical m/c which is designed to take the advantage of electromagnetic induction in ard er to convert mechanical energy into DC electrical energy.

Faraday's law of Electro magnetic Induction :-

The phenomen of producing induced emf in a conductor through a change in magnetic field.



when the magnet is stationary then [near the coil] galvanometer is deflecting zero.

when the magnet is moved near to the coil or inside the coil then galvanometer is deflecting in one direction If movement is fast then more deflection, if it is slow then less deflection. i.e; there will be change in the magnetic field due to movement Now change in magnetic field is responsible to produce induced emf in the coil.

whenever a conductor cuts a magnetic flux, a dynamically induced emf in the conductor

Ⅱnd law: The magnitude of induced emf is directly proportional to rate of change of flux linkages.

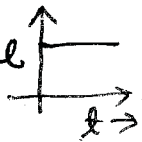
Flux: φ webers conductor: N Flux linkage $(\lambda) = \varphi \cdot N$

Flux linkage means the interaction between flux and conductor
↓ magnet ↓ cu wire

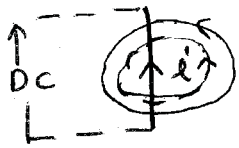
Induced emf
- Dynamically (AC in nature) (involved with motion or speed) flux cutting voltage
- Statically (AC in nature) (NO motion) i.e, stationary

Flux:-
ⓐ Time invarying flux / steady magnetic field
ⓑ Time varying flux

In time invarying flux, the flux is not varying w.r.t time



Ex-: Permanet magnet



when we give AC supply to conductor then we get continuously time varying current which is obviously produce time varying flux in it.

$$e = \frac{d\lambda}{dt} \text{ volts}$$

$$= \frac{d(N\varphi)}{dt} = N\frac{d\varphi}{dt}$$

$$\boxed{e = N\frac{d\varphi}{dt} \text{ volts}} \qquad \boxed{e = -N\frac{d\varphi}{dt} \text{ volts}}$$

-ve sign represent lenz's law

$$e = \left(N\frac{d\varphi}{di}\right)_{L} \times \frac{di}{dt} \qquad e = -L\frac{di}{dt} \text{ volts}$$

conductor behaves like inductor.

when there is rate of change of flux linkages conductor behaves as an inductor. Inductor will opposes the change in current so to communicate the opposition factor we put negative sign This negative sign doesn't represent any polarity or motion in DC m/c.

→ If the flux is time invarying in nature, it requires relative motion between flux and conductor for effective rate of change of flux linkages (one should rotate w.r.t other)

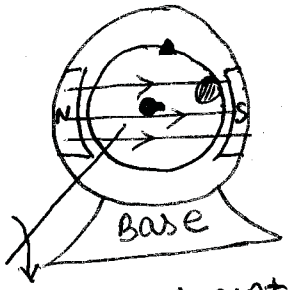
→ If the flux is time varying then it automatically produces voltages with stationary conductor because of inherent rate of change (No need of relative motion)

Three mode of flux linking :-

① Flux : Flux is stationary and nature is time invarying.

conductor : Rotating

magnet : stationary then flux will be stationary & having time invarying nature



Place a conductor on rotating part & don't rotate the rotating part then there is flux and conductor but missing the rate of change of flux linkage

If we want to create rate of change of flux linkage in time invarying flux then we require one should rotate w.r.t to other. i.e. either flux or conductor any one should rotate w.r.t. other then relative motion occurs → rate of change of flux linkage occurs produce induced emf.

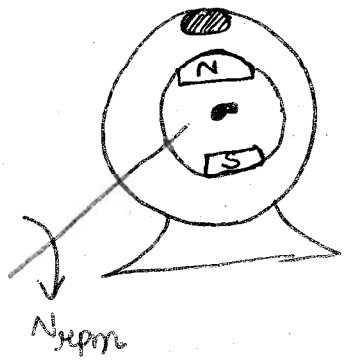
Ex : DC machine (Dynamically induced emf)

↳ Rotation is involved

② Flux: Flux is Rotating and nature is Time invarying

conductor: Stationary

in this when we start rotating then magnet is also rotate due to which flux is rotating but flux is time invarying only.



Rate of change of flux linkage occurs in conductor which produces dynamically induced emf.

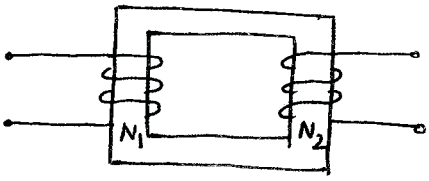
Ex:- Synchronous machines

To collect the current from stationary part is so easy.

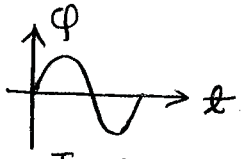
(2) Flux: Stionary & Time varying

conductor: stationary

DC voltage :→ ϕ ↑ ↓ & conductor



is @ stationary there is no rate of change of flux linkage. Never work on DC.

AC supply → 

Time varying → natural rate of change of flux linkage → enough to produce induced emf

Ex:- Transformer (Induction m/c is nothing but rotating X-mer) (statically induced emf)

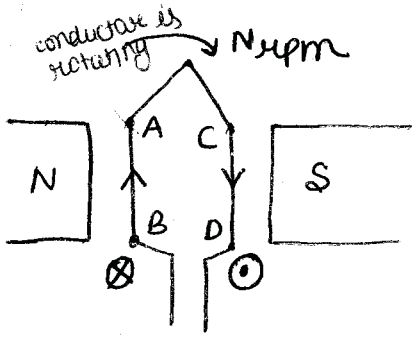
↳ NO motion require

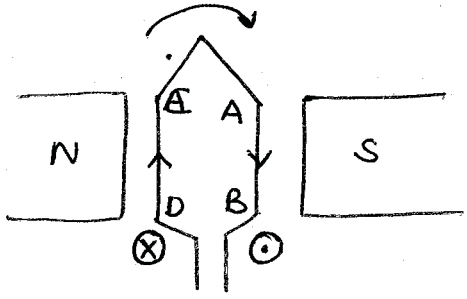
<u>working of a simple loop generator</u>:-

In order to produce induced emf in a conductor, require

(a) flux (b) conductor (c) prime mover According to FLEMI

Rotate the conductor b/w magnetic field.





is ving D ↑AB ○ CD↓ CD is moving down

[0°-180°] mechanical degree

↑CD ○ AB↓

[180°-360°] mechanical degree

we use Fleming's right hand rule in order to know dynamically induced emf.

$e = Blv\sin\theta$

B = flux density (Tesla)

l = Active length of conductor
i.e, length who cut the flux

V = peripheral velocity = $\frac{\pi DN}{60}$

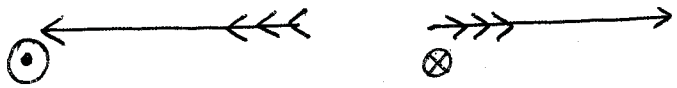
θ = angle between flux & conducto

D = Diameter of armature

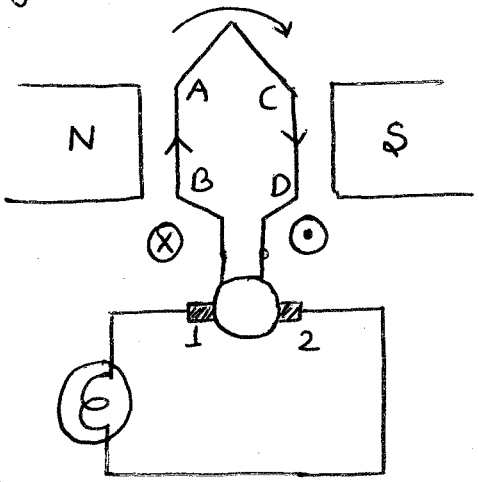
Fleming right han's rule :-

Forefinger → Flux Thumb → Motion force

middle finger → Direction of current or induced voltage in conductor [To know]



when blub is connecting to it then bulb is also get rotated which is problem for the designing purpose. For to be stationary the load we need idea which is sliding contact. But if we use one ring then it short circuit the coil.



So, we go for two ring concept

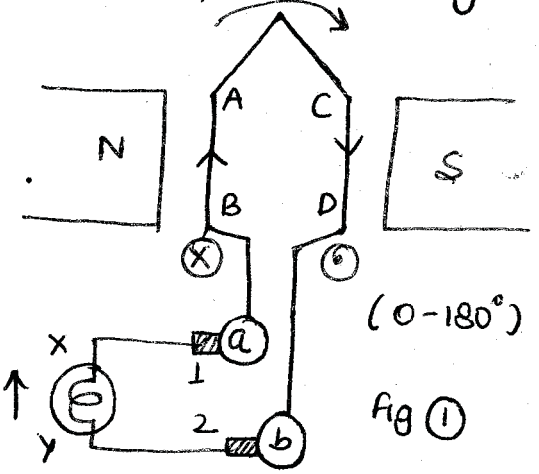


Fig ①

current direction : B A C D b 2 y x 1 a B

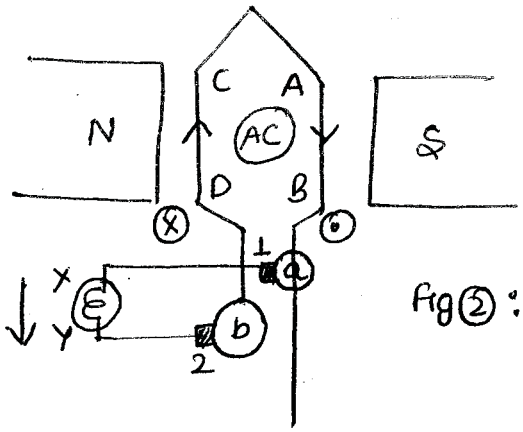


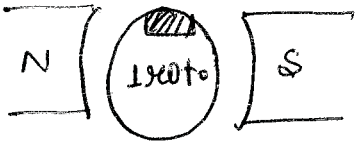
Fig ② :

current direction : DCABA 1 X Y 2 b D

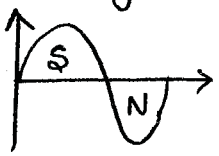
Bidirectional current in coil i.e; AC

in the coil : AC | in the bulb : AC | i.e; thus is AC generator.

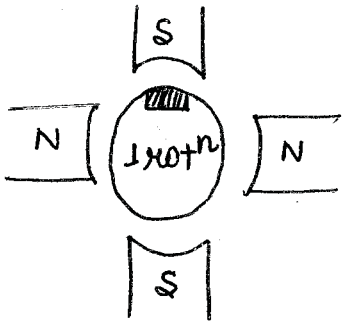
AC is collected as AC when connect two ring as slip ring.

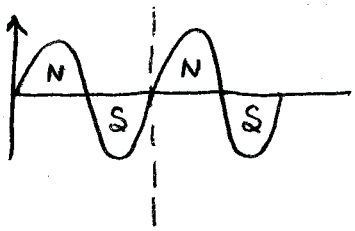


when conductor make one rotation then conductor will pass south pole and then also north pole. so, if south pole produce one pulse then north pole produce opposite. [There is no rule is south pole producing + or -ve & North pole producing +ve or -ve]



with 2 pole : 1 cycle in one rotation





with 4 pole : 2 cycle in one rotn

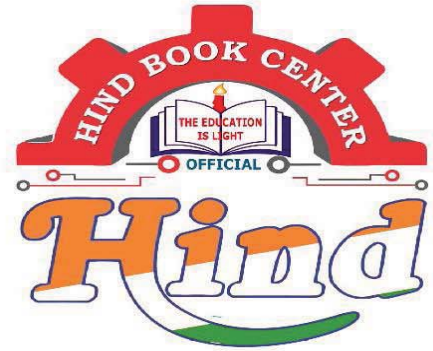
with P pole : P/2 cycle/rotn

No. of cycles/rotation = $P/2$

No. of Rotation/sec = $N/60$ N is in rpm.

$$\frac{\text{cycles}}{\text{rotation}} \times \frac{\text{rotation}}{\text{sec}} = \frac{P}{2} \times \frac{N}{60}$$

$$f = \frac{\text{cycle}}{\text{sec}} = \frac{PN}{120} \quad \text{or} \quad N = \frac{120f}{P}$$



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Topics:

(i) Power semiconductor devices

(ii) phase controlled rectifier (AC–DC) and Appli: Charging battery
DC Drive
solar cell

Power semiconductor devices :–

(i) Power diode
(ii) SCR (thyristor)
(iii) LASCR
(iv) ASCR
(v) RCT
(vi) GTO
(vii) TRIAC
(viii) DIAC

Power transistor (f↑)
③ → power BJT
① → power MOSFET
② → IGBT
↳ switching frequency order

cycloconv. ⇐ AC → DC → DC → AC

Power electronics :–

Static V–I characteristics and firing / gating circuits for thyristor, MOSFET, IGBT; DC to DC conversion : Buck and Buck-Boost converters; single and three phase configuration of uncontrolled rectifiers; voltage and current commutated Thyristor based converters; Bidirectional ac to dc voltage source converters; Magnitude and phase of line current harmonics for uncontrolled and thyristor based converters; Power factor and distortion factor of ac to dc converters, VSI, CSI, PWM.

Topics:

(i) Power semiconductor devices

*(ii) Phase controlled Rectifiers (AC $\rightleftharpoons$ DC)

and application : charging Battery : DC drive

: Solar cell : HVDC

Solar energy can be stored in the form of DC system but our utility system are in AC system. so conversion is needed and this is possible by using phase controlled Rectifier. (converter).

Suppose we want to control the DC machine then phase controlled Rectifier is used.

*(iii) switched mode DC $\longrightarrow$ DC converters (choppers)

*(iv) switched mode DC $\longrightarrow$ AC converters (inverters)

(v) AC drive

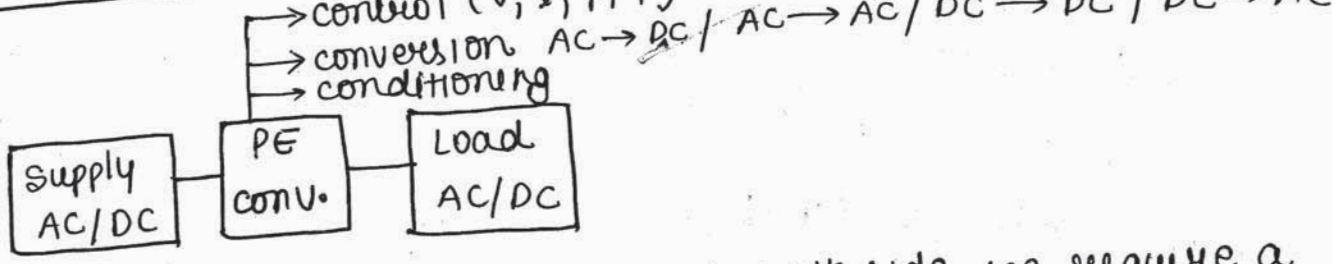
only for E&E

(vi) Resonant converters

(vii) High frequency T/F and Inductors for PE Application.

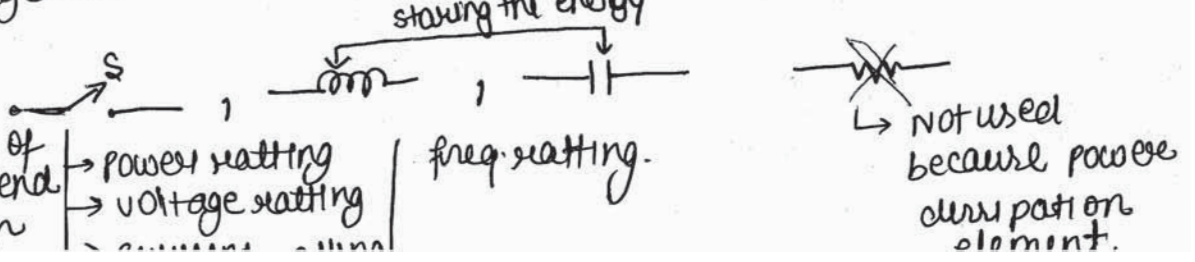
(viii) SMPS

Power electronics :- ?

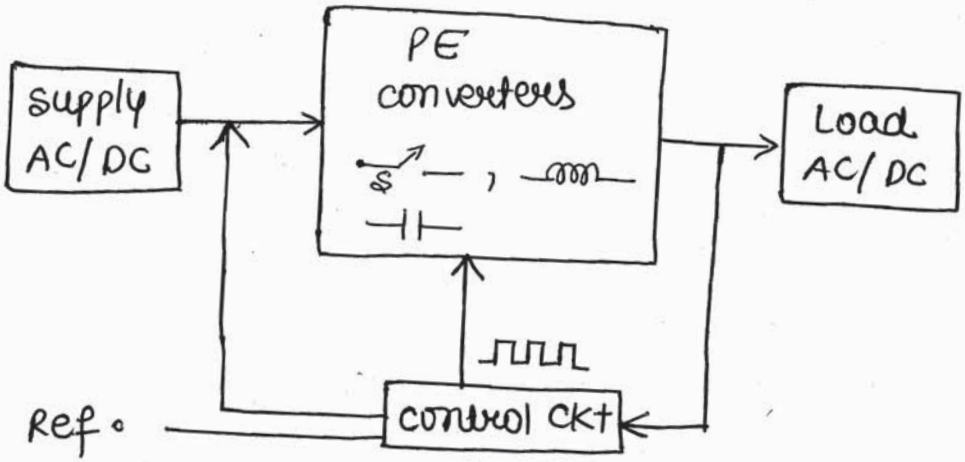


Due to the mismatching of power in both side we require a device which is known as power converters.

Between the sensitive load & power supply we use Power electronic converter so to minimize the voltage fluctuation. Ex-: stablizer to Refrigerator. i.e; conditioning of electrical power



(ON/OFF)
control the switches we need control ckt and it is low power circuit or signal level ckt. Here we can use resistive element.



Power electronic deals with control, conversion and conditioning of electric power using semiconductor devices & these SC devices should operate with high efficiency. In power electronic, semiconductor devices are mainly used as switches.



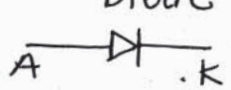
In this devices there will be two terminal Anode(A) & cathode (K). But some of the devices are also having Gate terminal also.

Suppose diode is only having two terminal Anode & cathode not having Gate(G) terminal that's why diode is uncontrolled device.

cycloconverter : V_0, f_0 (AC → AC)

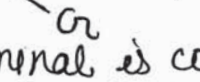
High power & low speed in drive

Semiconductor switches :-

(i) Uncontrolled switch : (eg) 

, DAIC

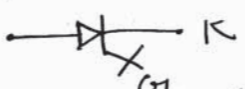
In the diode device there is no gate terminal so the ON/OFF state of diode will not decide then who decide the ON/OFF state of device? Nature of the ckt will decide it.

(ii) Semicontrolled switch : (eg) 

, TRAIC

In SCR, the anode & cathode terminal is connected to the supply & load respectively & Gate terminal is only decide the ON state but we can not decide the turn OFF time by using Gate terminal.

(iii) Fully controlled switches : (eg) GTO

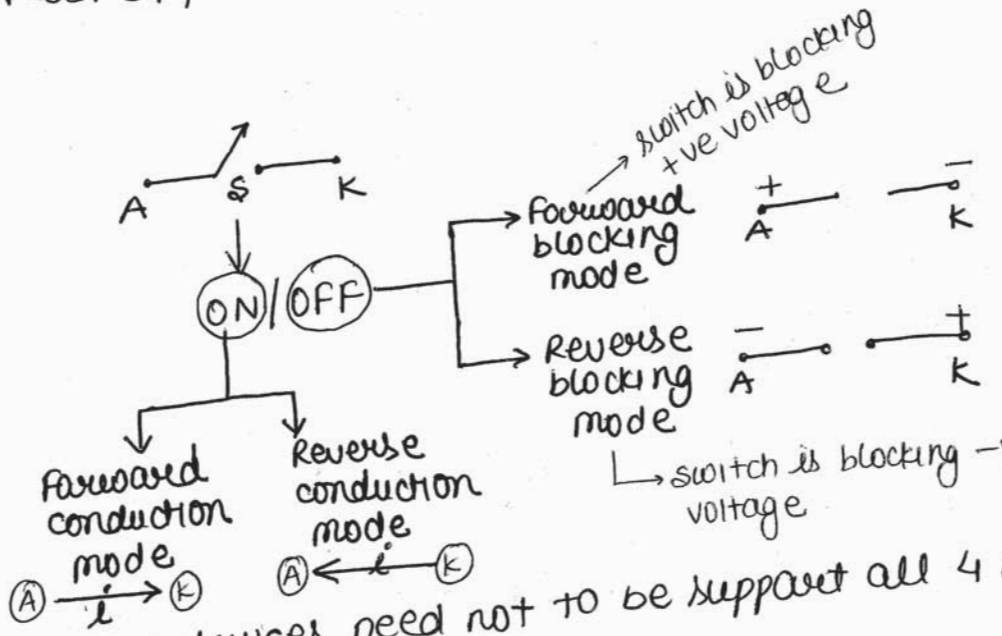


Gate is controlled terminal which decide both ON & OFF state.

when we give $+I_g$ to Gate terminal then GTO ≡ ON

$-I_g$ to Gate terminal then GTO ≡ OFF

(eg) BJT, MOSFET, IGBT

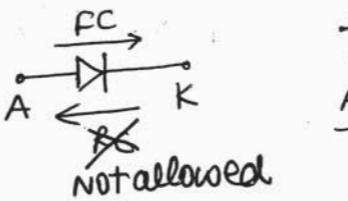


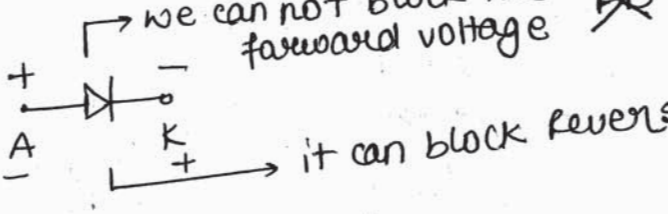
NOTE :-

All the semiconductor devices need not to be support all 4 mode.

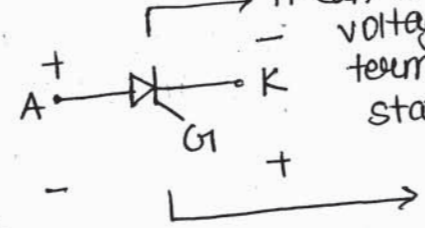
Eg :-

Diode





SCR



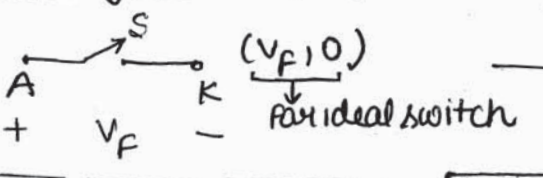
FB RB

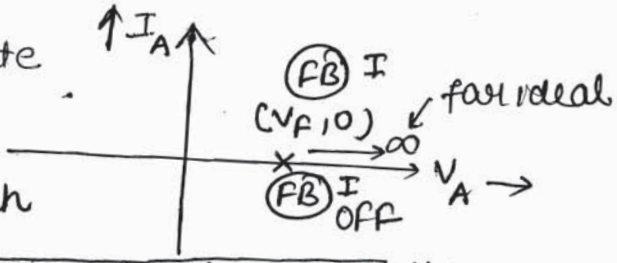
bipolar blocking capability

Diode	SCR
FC, RB	FB, RB, FC bipolar capability blocking with unidirectional current

Four-mode of an ideal switch :-

(i) Forward blocking mode : i.e, 'OFF state

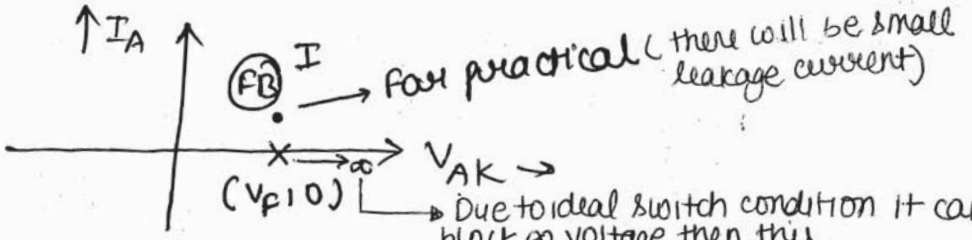




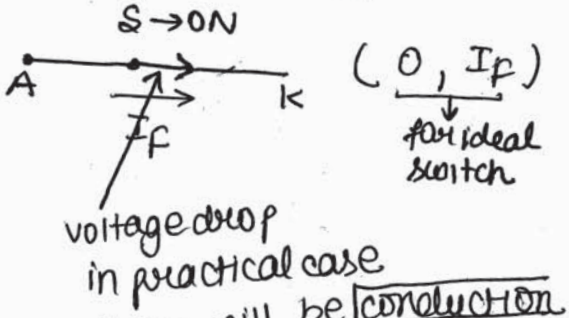
An **ideal device** **when blocking** the **forward voltage (V_F)** then **current passing** through the device **is zero Amp** but in **practical** some **leakage current** flow through it due to **minority current**
Now, we are having some losses in semiconductor device even in the OFF state i.e, **blocking power loss** = $[V_F \times I_{leakage}]$
If it is **ideal switch** then it **can block ∞ voltage** through it.
But practically it is not possible to apply ∞ voltage across it.

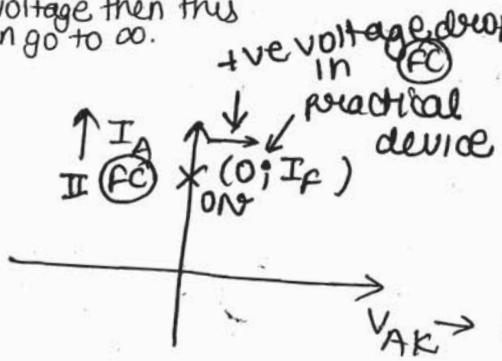
voltage rating : that much maximum voltage semiconductor device can block. [withstand in blocking state]

X → ideal
• → practical



(ii) Forward conduction mode : (FC)

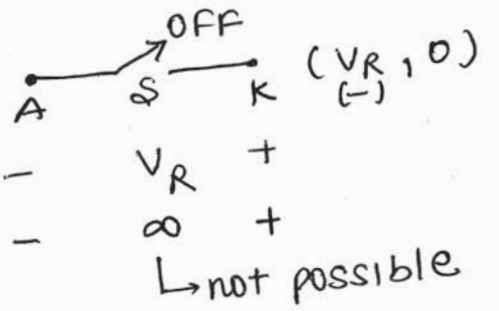


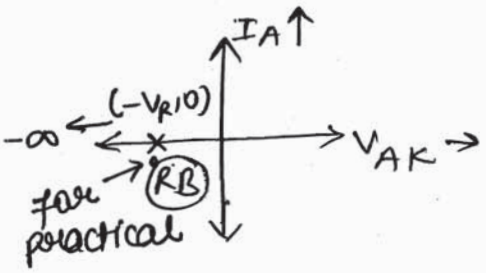


there will be **conduction loss** in the device
$= (V\text{-drop}) \times I_f$ → **major loss among all three losses**

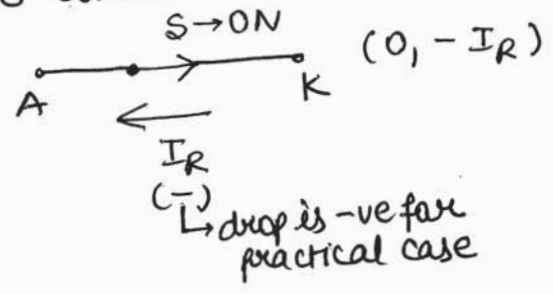
Switching power loss : The **variation of current & voltage** from (FB) **mode to** (FC) mode there will be loss in it which is known as switching power loss.
It is depend on the switching frequency of switch (f) if
f ↑ then **switching power loss ↑**

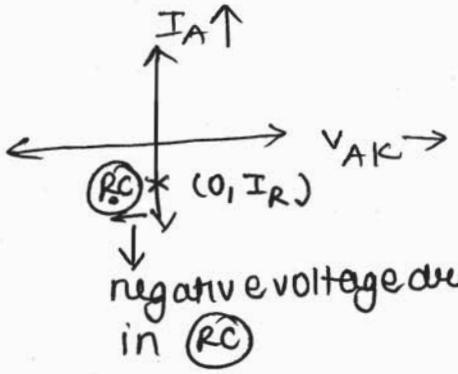
(iii) Reverse blocking mode (RB) :-





(iv) Reverse conduction mode (RC)



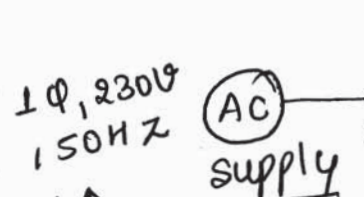


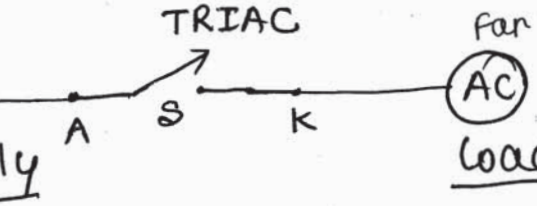
TRAIC supports all the 4 modes

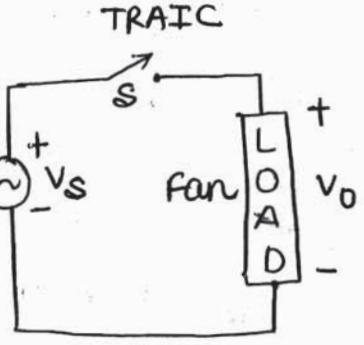
↳ **AC → AC converter**

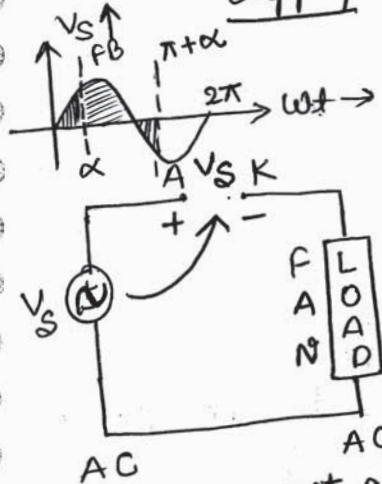
in these converter we use that switch which support all the 4 modes.

eg **controlling** the **fan speed** by **regulator** i.e; **controlling** the voltage V_{ac} **without disturbing the frequency**.





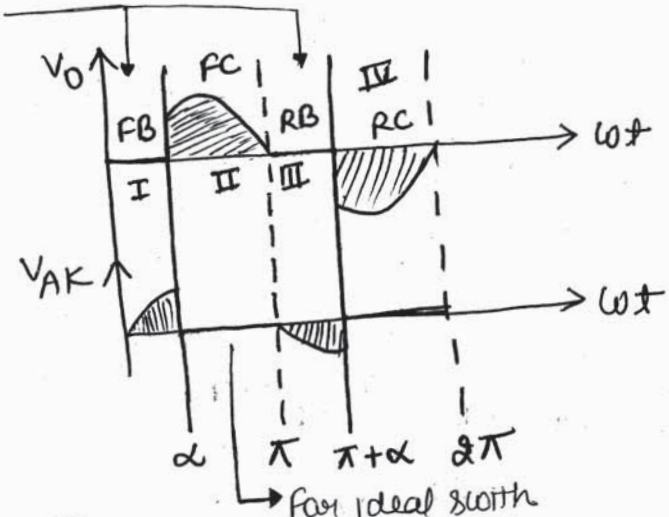




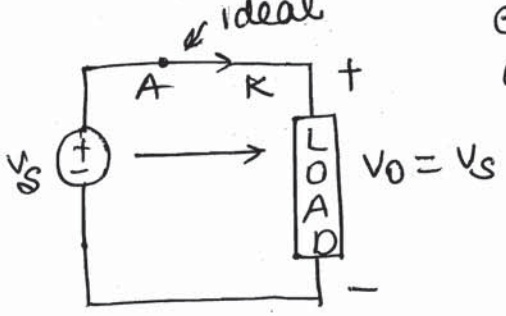
when we are not giving supply to Gate terminal + Then entire voltage appear across the switch. ($V_{AK} = V_S$) & $V_0 = 0$

↳ FR [let up to α]

when $I_g = 0$;

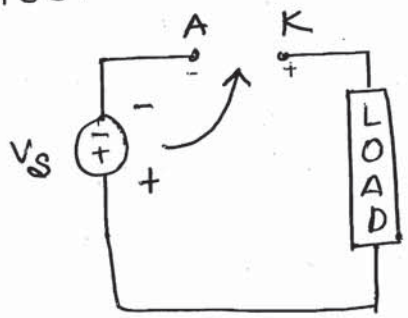


(II) mode –: Giving Gate signal to the TRIAC then TRIAC will turn ON & conduction in the forward direction

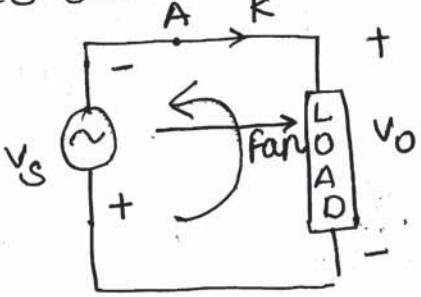


entire supply voltage appears across the load.

(III) mode–: Now the supply voltage is reverse (–ve) again it blocking the reverse voltage because did not give gate signal to TRIAC. Then entire –ve voltage appear across the device.



(IV) mode –: Now, giving $-I_g$ (negative pulse) signal to the TRAIC the TRAIC start conduction in reverse direction



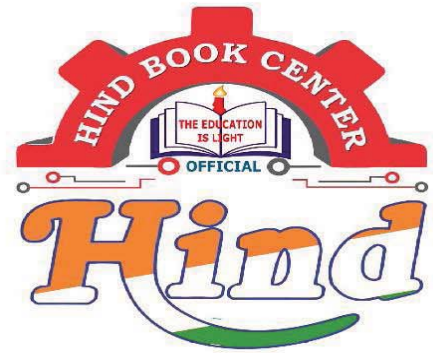
Negative voltage appear across the load.

Tell me how do we vary the voltage?

→ AC voltage is measure in the form of RMS voltage value.

how do we control the RMS value.

control the both area symmetrically (voltage graph) to eliminate the dc component. (or) area of both must be equal in order to eliminate the dc component. How much time we block the positive voltage same time we must block negative voltage so that both area should equal. Make sure that in AC side; DC component is always eliminated.



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measurement of P.f
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CRO
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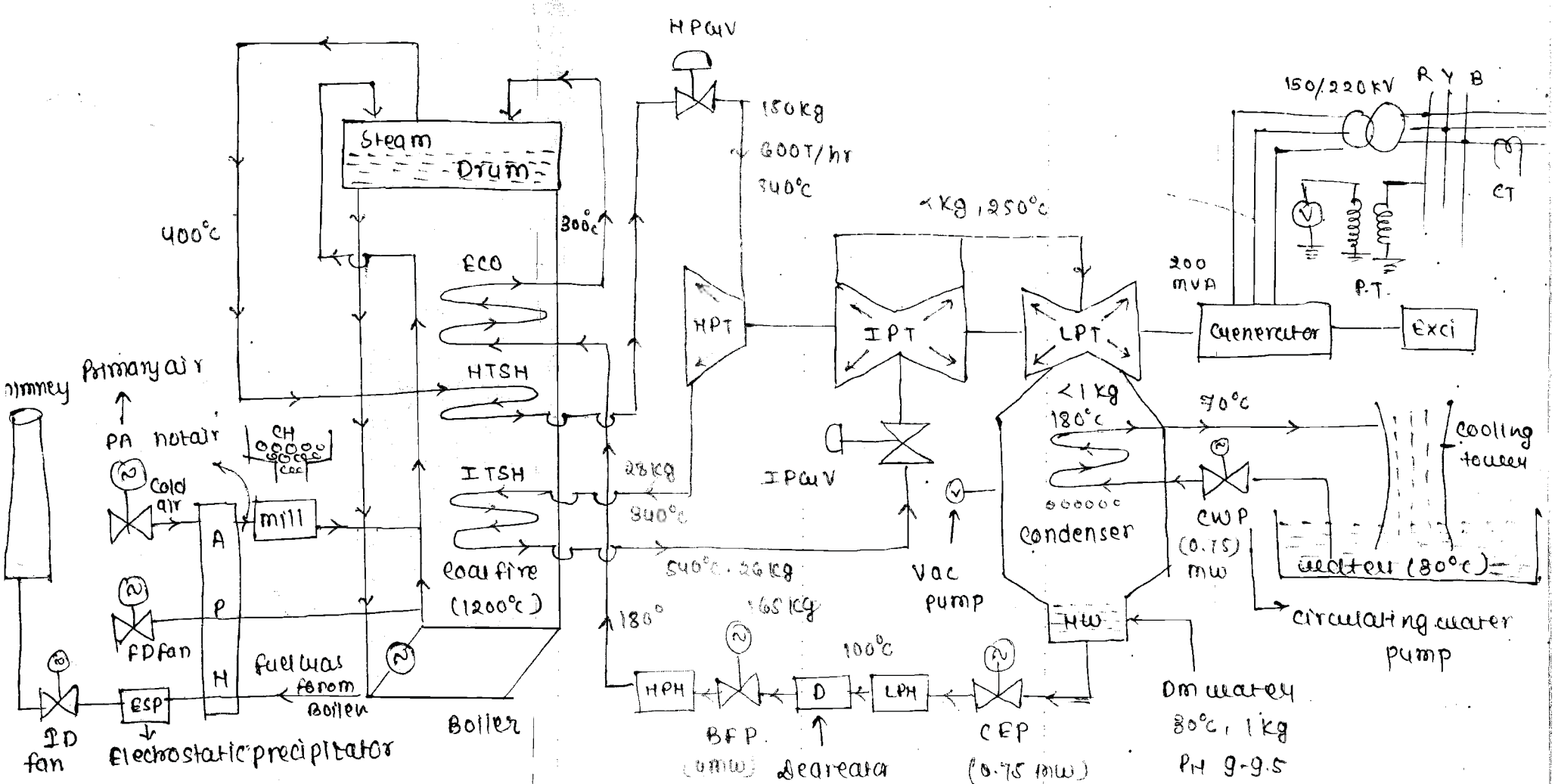
Thermal power plant

Chemical (coal)
↓ Boiler
Heat
↓ turbine
mechanical
↓ generator
Electrical

Principle - Rankine cycle.
(Reheating of steam)

* DM - Demineralize water (Base)
* CEP = Condensate extraction pump
* BFP = highest temp raising pump
* HPH = High pressure heater (step by step temp ↑ing)
* When coal fire temp around 1200°C
* Eco = Economiser which takes water in 180°C and give it in 300°C
* BFP = Boiler feed pump
* Inside drum there is a mechanism called turboseperator which separate water and steam.
* HTSH = High temperature super heater (steam will pass & its temp raise to 540°C)
* HPGV = High pressure governing valve, IPGV = Intermediate pressure governing valve
* ITSH = Intermediate temperature super heater
* ESP = electrostatic precipitation
* ESP = collection of air particle
* ID fan (Induced fan) - taking flue gases from boiler
* for sending coal into boiler moisture has to remove so for this we use air pre heater (APH) (moisture absorbed by hot air)
* Transportation cost is very high for thermal plant.
* BFP - Highest pressure pump
* Deareator = Remove dissolved gases
for improving thermal of economiser is used
* FD fans - sending oxygen to boiler for proper combustion
(it will take atmospheric air used for proper combustion)

* HW = Hot water


HPaV
150kg
600T/hr
540°C
Steam Drum
400°C
300°C
ECO
HTSH
ITSH
coal fire (1200°C)
HPT
IPT
LPT
1kg, 250°C
IPaV
28kg
540°C
540°C, 26kg
165kg
180°
Vac pump
<1kg
180°C
condenser
70°C
CWP
(0.15) mw
cooling tower
water (30°C)
circulating water pump
HW
DM water
30°C, 1kg
PH 9-9.5
150/220KV
R Y B
CT
PT
200 MVA
Generator
Exci
Primary air
PA
hot air
CH
Cold air
mill
A
P
H
FD fan
fuel gas from Boiler
ESP
ID fan
Electrostatic precipitator
Boiler
HPH
BFP
(0mw)
D
deareata
100°C
LPH
CEP
(0.75 mw)

$\eta_{thermal} = 40\text{-}45\%$

$= \eta_B \times \eta_t \times \eta_{GA}$

$\downarrow \quad \downarrow \quad \downarrow$

$90\% \quad 30\text{-}40\% \quad 90\%$

now η due to condence heat loss

Bituminous coal used

Coal chemical / heat Energy

= Calorific value $\Rightarrow C_F \Rightarrow$ Kcal

860 kcal Heat energy = 1 kwhr elect energy

Practical

$\eta_{thermal} = 40\%$

Bituminous coal : $C_F = 1720$ K cal / kg

$1\text{ kg} = \frac{1720}{860} \times 0.4 = 0.8$ kw-hr

$1\text{ kwhr} = \frac{1}{0.8} = 1.25$ kg cal

Generator - 200 mw , 1 day - 24 hrs

coal/day $= 200 \times 10^3$ kw $\times$ 24 hrs $\times 1.25$ kg

$= 6000 \times 10^3$ kg $= 6000$ T/day

(1) C_F in kcal/kg

$$Q = \frac{P_{avg} \times T \times 860}{\eta_0 \times C_F}$$

2) C_F is kwhr/kg

$$Q = \frac{P_{avg} \times T}{\eta_0 \times C_F}$$

Analog meter

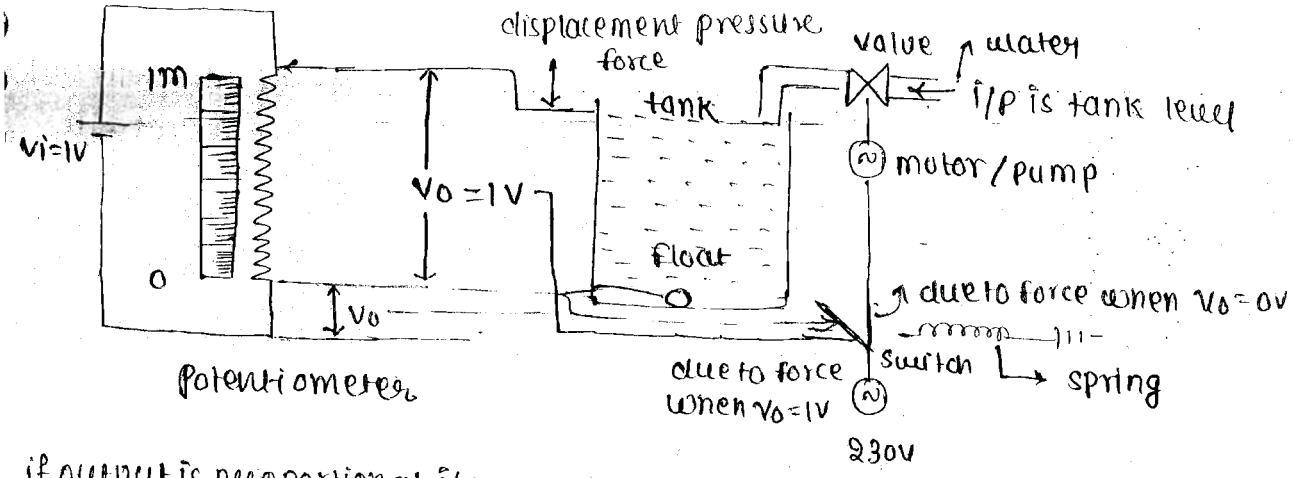
- **Measure**
  - V
  - I
  - P
  - P.F
  - Energy
- **principals**
  - Electromagnetic
  - electrostatic
  - thermal
- **Representation**
  - **Indicating meters** → Voltmeter (V), ammeter (A), watt meter (W)
  - **Integrating meters** → Energy meter, A-hr meter
  - **Recording meters** → Galvanometric, Potentiometric
  - **Nulldetector** → Potentiometer

Order of the Meter

the instrument or meter should behave similar to the quantity to be measured (measurand)

1. **Zero order instrument** - when I/P changing O/P following the I/P immediately called zero order (0 time delay)

Potentiometer



if output is proportional I/P and the O/P is changing at the same instant of I/P is changing without any time lack and time delay is called zero order system

ex. Potentiometer

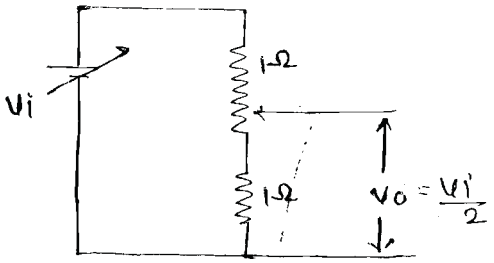
when tank level is full so current will flow creates magnetic field there for switch comes to open position

and when Vo=0 V and material ≠ 0 so it will experience force

1 m = 1 volt

100 cm = 1 volt

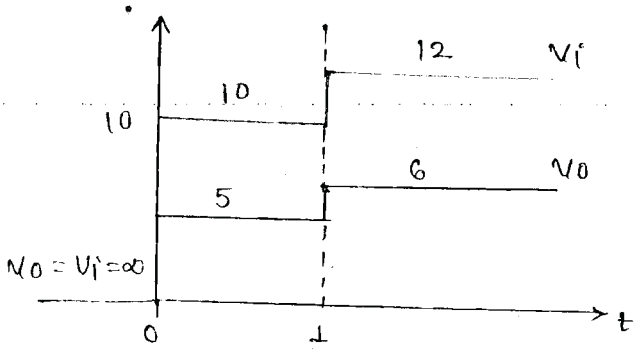
1 cm = 0.01 volt



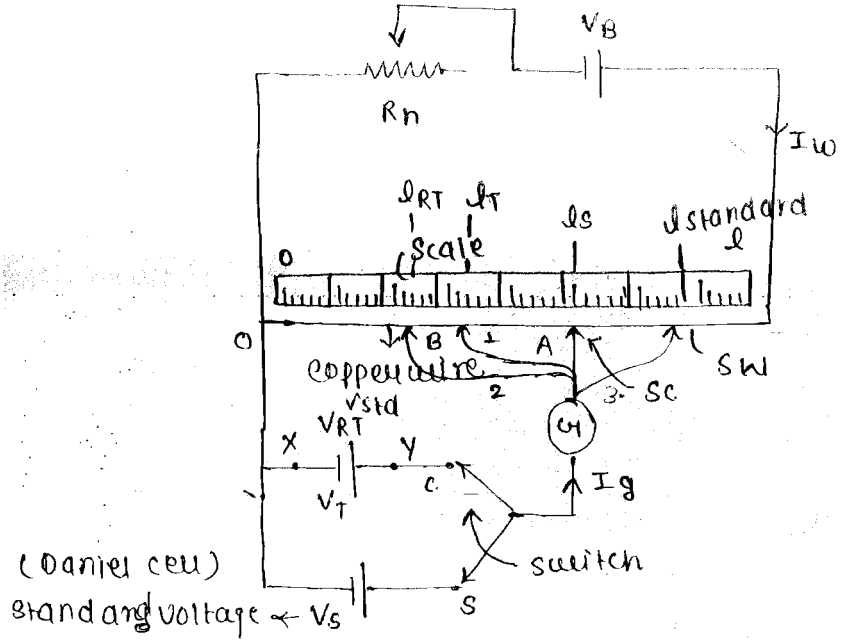
$$T(s) = \frac{V_o}{V_i} = \frac{1}{2} = K$$

= Constant

$$\frac{C(s)}{R(s)} = K = \text{constant}$$



Practical potentiometer



V_B = External Battery

R_h = Rheostat

I_w = working current

l = length of slide wire (m)

$\mathcal{R}$ = Resistance of slide wire (Ω/m)

l_{RT} = total resistance of slide wire (Ω)

SW = Slide wire

Sc = Sliding contact / Jockey

(G) = Galvanometer

S = Standardization

C = Calibration

V_s = Standard voltage source

V_T = test voltage

Convert centimeter scale into voltage called standardisation

Once standardize never change working current

Put galvanometer to make $I_g = 0$

then move the switch to C so V_T will drawn some current $I_g \neq 0$ then will move jockey to some value where $I_g = 0$ not disturb rheostat

Application

1. Measurement of V_T:

$$I_\omega = \frac{V_B}{R_h + l_r}$$

Switch at S

$$I_\omega (l_{sr}) = V_S$$

$$I_\omega = \frac{V_S}{l_s \mathcal{H}} \quad \text{—— (1)}$$

Switch at C

$$I_\omega \, l_T \cdot \mathcal{H} = V_T$$

$$I_\omega = \frac{V_T}{l_T \cdot \mathcal{H}} \quad \text{—— (2)}$$

(1) = (2)

$$\frac{V_S}{l_s \mathcal{H}} = \frac{V_T}{l_T \cdot \mathcal{H}}$$

$$\frac{V_S}{l_s} = \frac{V_T}{l_T}$$

l_s = length of switch at which V_S is balanced

l_T = length of switch at which V_T is balanced

balanced condition means making $I_g = 0$

will take reading when $I_g = 0$ or null therefore potentiometer is called null detector

2. Measurement of low Resistance ($< 1\Omega$)

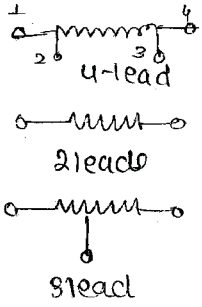
Classification of R

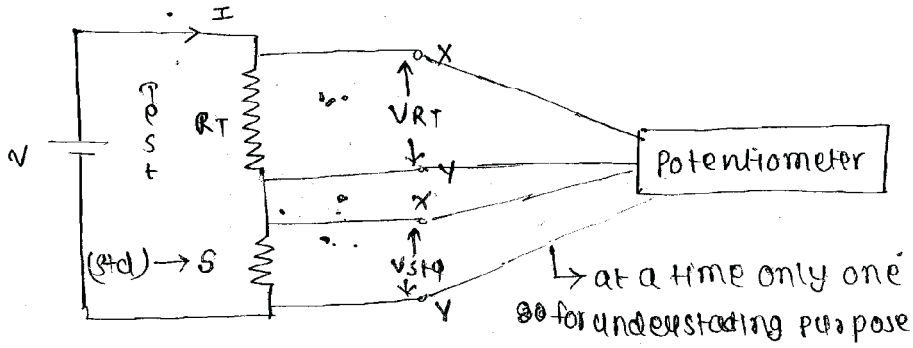
(1) low R — $R < 1\Omega$ — T/F, (M), (M) winding

(2) medium R — $1\Omega \lesssim R \lesssim 100\,K\Omega$ — Heater, iron box, electronic equipment

(3) High R — $R > 100\,K\Omega$ — insulation cable, (M), (M), T/F

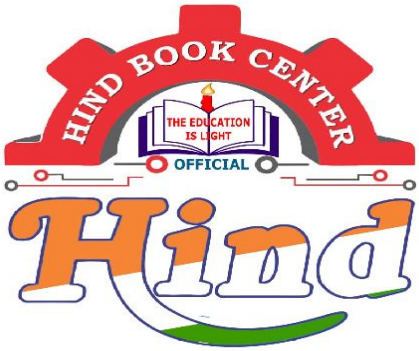
Representation





→ at a time only one x-y connection is there

for understanding purpose I have shown both



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Books:-

1) Semiconductor Physics and Devices
— DONALD NEAMEN.

2) GATE
- Basics
- Diode
- **FET

} Solved Examples of Donald Neamen.

*CLASSIFICATION OF TEMPERATURE (T):-

* Divided into three parts:-
  1) ABSOLUTE TEMPERATURE (0K = -273°c)
  2) ROOM TEMPERATURE (300K = 27°c)
  3) AMBIENT TEMPERATURE (T_A) (290K = 17°c)

** $^oK = K$ (old Notation → New Notation)

* Absolute Temperature is Practically not Possible. It is only the Reference Temperature, and never used in Reality.
* Absolute Temperature is just a Reference temperature
* At Room temperature, all properties of Semiconductor Devices are maxm at Room temperature.
* All Properties of Comm^n systems are taken at the Ambient Temp. ie 290K or 17°c.
* ** **TEMPERATURE in KELVIN = TEMPERATURE in °c +273**

*THERMAL VOLTAGE (V_T) :-

* Also called as the "VOLT EQUIVALENT OF TEMPERATURE".
* Most of S.C devices properties changes with temperature.
* Mathematically,

** $$V_T = \frac{\bar{K}T}{q} \text{ volts}$$

Where, T = Temperature in Kelvin
q = Magnitude of charge (1.6×10^{-19} C)
$\bar{K} = 1.381 \times 10^{-23}$ J/°K

Also, $V_T = \frac{T}{11600}$ volts

Hence,

i) At $T = 0K \Rightarrow V_T = 0$ volts

ii) At $T = 300K \Rightarrow V_T = \frac{300}{11600}$

** $V_T = 0.02568$ volts
$= 26$ mV.

Note :-

1) For a large variation in Temperature, the variation in the Thermal voltage is negligible.

* BOLTZMANN CONSTANT :-

$\bar{K} = 1.381 \times 10^{-23}$ J/°K

$K = 8.62 \times 10^{-5}$ eV/°K

Hence, ** $\bar{K} = 1.6 \times 10^{-19}$ K

Hence, $V_T = \frac{\bar{K}T}{q} = \frac{qKT}{q}$

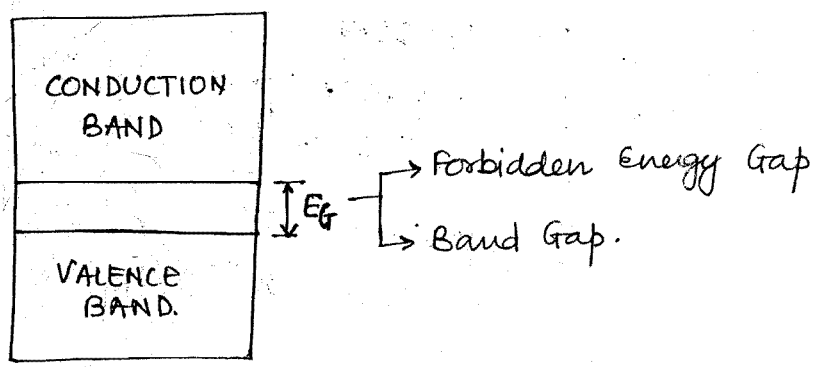
** $V_T = KT = \frac{\bar{K}T}{q}$

↳ Numerically equal values.

* ENERGY GAP (E_G or E_g) :-

* Gap between Valence Band and Conduction Band is called as Energy Gap.

* Band diagram of Semiconductor (SC) is given as :-



*

	E_{G0}	E_{G300}
Ge	0.782 eV	0.72 eV
Si	1.21 eV	1.1 eV

** * Energy Gap decreases with Temperature in a semiconductor. Mathematically,

** $$E_G \propto \frac{1}{Temp}$$

* To calculate E_G at different temp we can use:

** $$E_G(T) = E_{G0} - \beta_0 T \ (eV)$$

β_0 = material constant (eV/°K)

* For Germanium:

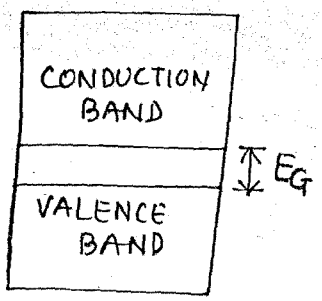
$$E_G(T) = 0.782 - 2.33 \times 10^{-4} T \ (eV)$$

* For Silicon:

$$E_G(T) = 1.21 - 3.6 \times 10^{-4} T \ (eV)$$

* for a semiconductor, Energy Gap is small

** $$E_G \leq 1.5eV$$



Note:

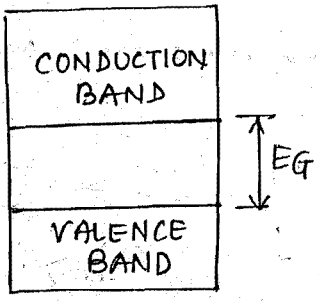
1) Semiconductors are BIPOLAR
2) Semiconductor can contribute DIFFUSION CURRENT.
3) Semiconductor has NTC of RESISTANCE

** $$T\uparrow \ R\downarrow$$

*Note:-

* For Insulators, the Energy Gap is large

↳** $E_G > 5eV$



*Insulators are Bad Conductors of Current, and their Conductivity is negligible.

*For Ideal Insulator, Conductivity is Zero.

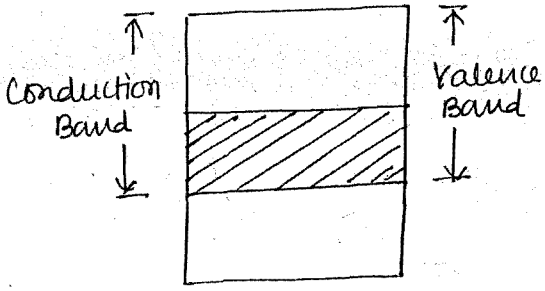
Note:-

1) If Energy Gap is small, less amount of additional energy is required for the $e^{\ominus}$ to jump from "VALENCE BAND" to "CONDUCTION BAND"

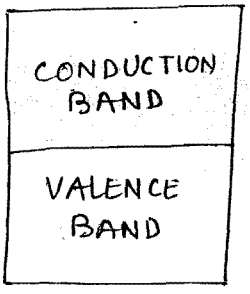
* For Metals (Conductors):-

↳ $E_G = 0\,eV$ ← Practically negligible value.

↳(Non Zero Energy Gap)



(at T= 300K)



(at T=0K)

* For metals, the conductors ~~and~~ the Conduction Band and Valence Band overlap each other and the overlapping increases with Temp.

*Conductivity is very large in Conductors

* Only DRIFT CURRENT flows in Conductor

*Conductors are unipolar, current carried only ~~in~~ by $e^{\ominus}$.

* PTC of Resistance:- ** $T \uparrow R \uparrow$ ← Exclusive Property of Metals

* Definition of Semiconductor :-

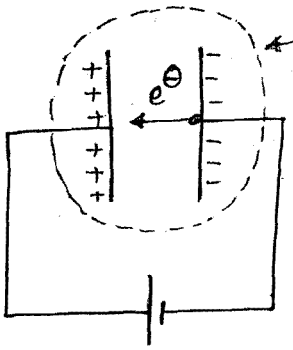
* Semiconductors are the elements whose conductivity lies in between in the conductivity of an insulators and the conductivity of a metal.

* ELECTRON VOLT (eV) :-

* Electron volt is a unit of ENERGY
* Very small unit of Energy (almost fraction of unit of Energy ie Joule).
* Electron volt is the unit of ENERGY in Electronics
** 1 eV is defined as the energy gained by the electron (e^-) in moving through a potential difference of 1V.

Note :-

* Air is a perfect insulator, the Best insulator.



Note :-

* $e^\ominus$ cannot move through air, hence air in the glass has been removed.
* $e^\ominus$ can move through Vacuum
  - for eg → Vacuum Tubes

Mathematically

$$1\,eV = |q| \times \text{Potential difference}$$

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

** $$= 1.6\times10^{-19}\,CV$$

Or $$\boxed{1eV = 1.6\times10^{-19}\ \text{Joules} = 1.6\times10^{-19}\ \text{Coulomb-Volt}}$$

Note :-

* Electron Volt is the Kinetic Energy Gained by the $e^\ominus$ or the Potential energy lost by the $e^\ominus$.

Mathematically,

** Kinetic Energy $= \frac{1}{2} mv^2$

m = mass of $e^{\ominus}$
$= 9.1 \times 10^{-31}$ Kg

** Potential Energy $= q \times V$

V = Potential difference

By definition:-

KE gained = PE lost

$\frac{1}{2} mv^2 = qV$.

** Velocity of $e^{\ominus}$, $v = \sqrt{\frac{2qV}{m}}$ m/s

* ELECTRIC FIELD INTENSITY ($\mathcal{E}$ or E) :-

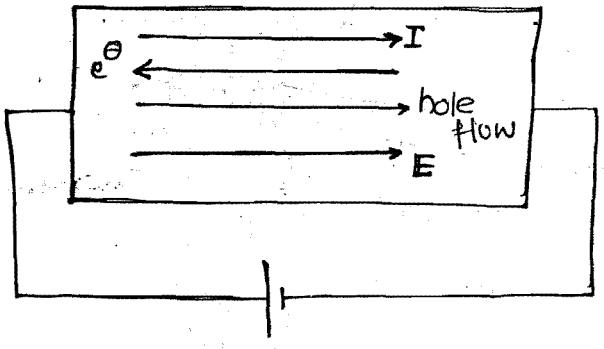
* Also called Field Intensity
* Also called as Field Gradient
* Also called as Field.
* Mathematically,

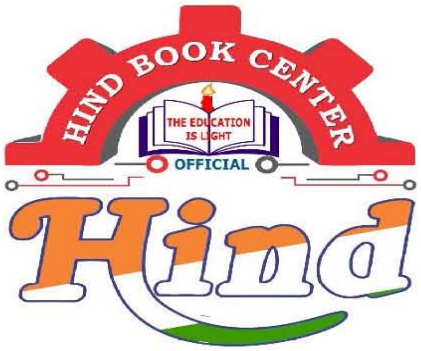
** $\mathcal{E}_0 = -\frac{dV}{dx}$ Volt/metre

Also, **

$|\mathcal{E}_0| = \frac{\text{magnitude of voltage Existing}}{\text{distance or space}}$

Note :-





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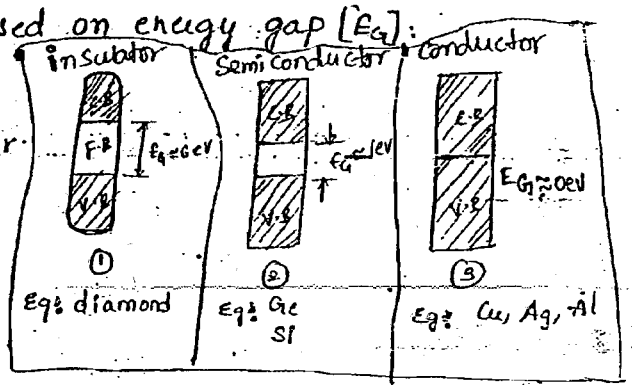
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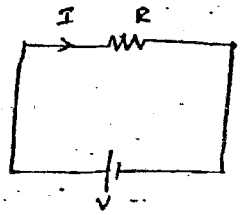
2. Conductor Materials

Note:- Classification of materials based on energy gap (E_G):

1) Insulator
2) Semi-conductor
3) Conductor



Ohm's Law Of Electricity :-



V is the applied voltage

I is the produced current

R is the resistance of a resistor

$$R = \frac{l}{\sigma A} = \frac{\rho l}{A} \ (\text{ohm})(\Omega)$$

According to ohm's law $V \propto I$

$V = \text{constant} * I$

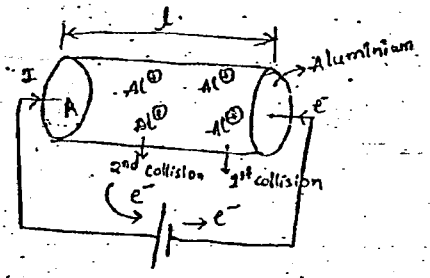
$V = RI$ —— ①

$\sigma \rightarrow$ electical conductivity $\left(\frac{1}{\Omega m}\right)$

$$\sigma = \frac{l}{RA} \left(\frac{m}{\Omega m^2} = \frac{1}{\Omega m}\right)$$

$\rho \Rightarrow$ electical resistivity (Ωm)

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



$$V = \frac{l}{\sigma A} I \Rightarrow \frac{I}{A} = \sigma \frac{V}{l} \Rightarrow \boxed{\vec{J} = \sigma \vec{E}} \text{ —— ②}$$

l = length of conductor

A = Cross sectional area

Force on election having 'm' mass and acceleration 'a' is

$F = ma$ —— ③

Force on election having 'q' charge due to applied electric field intensity 'E' is $\vec{F} = q\vec{E} \rightarrow \oplus$

③=④ $\Rightarrow ma = qE \Rightarrow a = \frac{qE}{m}$ —— ⑤

Drift velocity $v_d = a\tau_c$ —— ⑥

$\left(\frac{m}{sec}\right) \quad \left(\frac{m}{s^2}\right)(s)$

Put ⑤ in ⑥

$v_d = \frac{qE}{m}\tau_c$

$\vec{v}_d = \left(\frac{q\tau_c}{m}\right)\vec{E}$ —— ⑦

E = electric field intensity $\left(\frac{V}{m}\right)$

$\boxed{\vec{v}_d = \mu\vec{E}}$

μ = mobility = $\frac{q\tau_c}{m}$ $\left[\frac{m^2}{(Volt)(sec)}\right]$

$\vec{J} = nq\vec{v}_d$ —— ⑧

$\left(\frac{A}{m^2}\right) \quad \left(\frac{1}{m^3}\right)(q) \quad \left(\frac{m}{sec}\right)$

Put ⑦ in ⑧

$\vec{J} = nq\mu\vec{E}$ —— ⑨

Compare ② and ⑨

$\sigma = nq\mu$ —— ⑩

$\sigma = nq\left(\frac{q\tau_c}{m}\right)$

$\boxed{\sigma = \frac{nq^2\tau_c}{m}}$

n = electron density = $\frac{\text{number of electrons}}{m^3}$ $\left(\frac{1}{m^3}\right)$

q = charge of charge particle.

m = mass of charge particle.

τ_c = collision time (second).

τ_c is the average time b/w two successive collisions

NOTE: ** ① In conductor (or) metals when temperature is increased metal ions vibrate and number of collisions increase and collision time decreases, so conductivity decreases and resistivity increases. Metals

have positive temperature coefficient of resistivity and resistance.

It is found that $\tau_c \propto \frac{1}{\sqrt{T}}$

$$\sigma \propto n\tau_c$$

$$\sigma \propto \frac{n}{\sqrt{T}}$$

T = temperature

Factors affecting the resistivity:

(1) temperature (T): In conductor the temperature is increased the ρ increases according to the following equation

$$\boxed{\rho_T = \rho_{RT}(1+\alpha\Delta T)} \quad \text{---(1)} \quad \text{also} \quad \boxed{R_T = R_{RT}(1+\alpha\Delta T)}$$

ρ_T = resistivity of operating temperature

ρ_{RT} = Resistivity at room temperature (T_{RT})

$\Delta T = T - T_{RT}$

ΔT = Change of temperature

α = temperature coefficient of resistivity ($\frac{1}{°C}$ or $\frac{1}{°K}$)

α is positive for metals

R_T → Resistance at T temperature

R_{RT} → Resistance at Room temp (or) Reference temp.

$\Delta T = T - T_{RT}$ → Change of temp

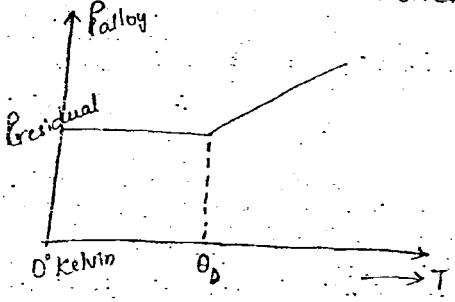
α = temperature coefficient of Resistance (or)

(2) Alloying effect: Adding impurity atoms to pure metals.

If percentage of alloy content is increased then irregularity in atomic arrangement increases, so resistivity increases (independent of temperature). This is called as residual resistivity ($\rho_{residual}$)

Total resistivity is $\boxed{\rho_{alloy} = \rho_{thermal} + \rho_{residual}}$ ---(2)

Eqn (2) is called as matthiessen rule.



θ_D is called as Debye temperature. It is the temperature after which ρ increases linearly w.r.t temperature

③ ** Deformation :

Deformation → change of shape (or) length (or) diameter (or) volume.

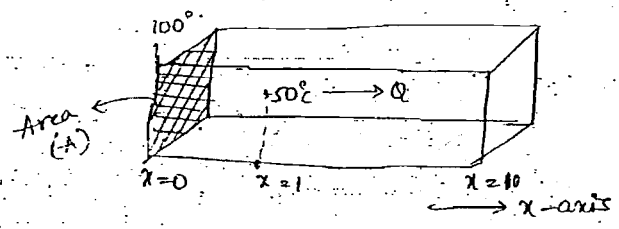
⇒ Deformation in conductors increases the irregularity of atomic arrangement. So ρ increases. This increase of ρ is called as $\rho_{deformation}$ for alloy having deformation

Total resistivity $\rho_{alloy} = \rho_{thermal} + \rho_{residual} + \rho_{deformation}$.

(residual: permanent i.e. independent of temperature)

Observation :

1) In conductors (or) metals thermal energy is transferred due to random motion of free electrons as well as vibrations of metal ions. But most of the % of ~~thermal~~ energy is transferred due to free electrons. In conductors the (Q) thermal power crossing the area is given by



$$Q = -k \frac{dT}{dx} \left(\frac{watt}{m^2}\right) \quad \text{—— (1)}$$

$\frac{dT}{dx}$ = temperature gradient $\left(\frac{^\circ kelvin}{m}\right)$

where k is thermal conductivity $\left(\frac{watt}{^\circ k \cdot m}\right)$

for conductors k due to free e⁻s is given by

$$k = \frac{1}{3} \frac{n \pi^2 k^2 T \tau_c}{m} \quad \text{—— (2)}$$

for conductors $\sigma = \frac{n q^2 \tau_c}{m}$ —— (3)

$$\frac{(2)}{(3)} \quad \frac{k}{\sigma} = \frac{\frac{1}{3} \frac{n \pi^2 k^2 T \tau_c}{m}}{\frac{n q^2 \tau_c}{m}}$$

$$\frac{k}{\sigma T} = \frac{1}{3}\frac{\pi^2 k^2}{q^2}$$ | K is Boltzmann constant, q is charge of electron

after substituting values we get

$$\frac{k}{\sigma T} = 2.45 \times 10^{-8}$$

$$\frac{k}{\sigma T} = L \quad \text{——④}$$

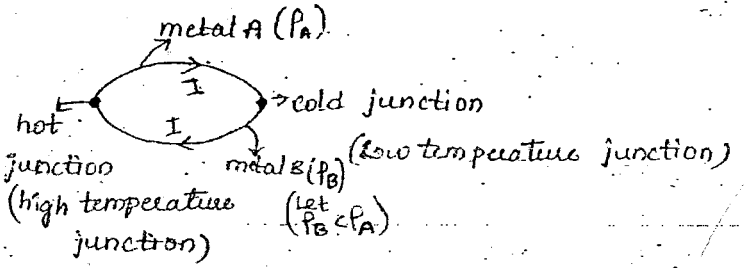
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$L = 2.45 \times 10^{-8}$ = Lorentz number.

Eqn ④ is called as weidemann Franz law of conductors, which says the ratio of thermal conductivity (k) and electrical conduct (σ) at any temperature (T) is constant

** Thermoelectric effects:

* Seebeck effect:-



If two dissimilar metals (A, B) having different resistivities are joined. If one end is maintained at high temperature, other is maintained at low temperature then electromotive force (emf) is produced. This emf makes the current flow in the loop. This is called as seebeck effect. ⇒ Seebeck invented thermocoupl

* Peltier Effect:- (converse of seebeck effect)

If two dissimilar metals are joined, if current is flown in the loop then one junction goes to high temperature and other junction goes to low temperature. This is called peltier effect. Peltier effect is used in refrigerator.

Types of Conductors:

i) Low resistivity conductors:

These are used in transmission and distribution of electrical current. Ex: Copper (Cu), Aluminium (Al).

ii) High resistivity conductors:

These are used in manufacturing resistors, electical heating devices, thermocouples. These materials must withstand high temperature. They are generally alloys of metals.

Ex: Constantan (60% Cu, 40% Ni)

Nichiome — 75 to 78% Ni, 20 to 30% Cr, 1.5% Mn, remaining is Fe

iii) Low melting point conductors:

Metals having low melting point are used in soldering joints.

Ex: tin, lead (Pb)

→ Soldering materials [Tin(Sn), Lead (Pb)] have low melting point and high electrical conductivity.

Note:- Tin (Sn): (i) tin is a silvery white (or) shining white colour (ii) Conductivity of tin is less (or) poor compared to copper ($\sigma_{Sn} = 0.917 \times 10^7 (\Omega\text{-m})^{-1}$ at 20°C) (iii) tin can be drawn into wires because it is soft and malleable (iv) tin is used in alloys with lead and copper (v) tin is used for fuses and cable sheathing. (vi) tin is corrosion Resistant because of formation of oxide layer.

ESE

(a) A Resistor measures 4Ω at 40°C and 6Ω at 80°C. At 0°C the resistor will measure (a) 1.5Ω (b) 2Ω (c) 3Ω (d) 4Ω

→ $R_T = R_0(1+\alpha\Delta T)$ where R_0 is Resistance at 0°C and $\Delta T = T - 0$

at $T = 40°C \Rightarrow 4 = R_0(1+\alpha 40) \rightarrow (2)$

at $T = 80°C \Rightarrow 6 = R_0(1+\alpha 80) \rightarrow (3)$

$(2) \div (3) \Rightarrow \frac{4}{6} = \frac{1+40\alpha}{1+80\alpha} \Rightarrow \alpha = \frac{1}{40} \rightarrow (4)$

put (4) in (2)

$4 = R_0(1+\frac{1}{40}40) \Rightarrow R_0 = 2\Omega$

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1947 - Transistor

SSI → < 10 Transistor (small scale integration)

MSI → 10 - 100 Transistor (Medium scale —" —)

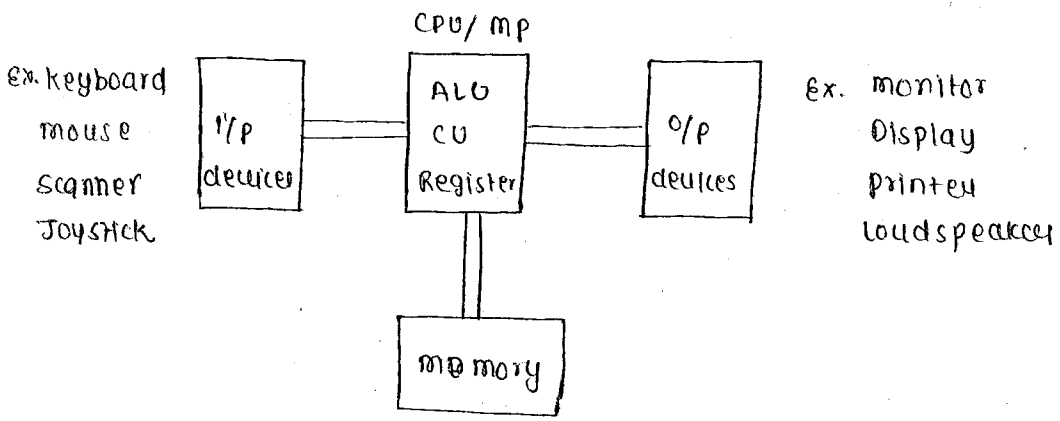
LSI → 100 - 10K Transistor (Large —" —" —)

VLSI → > 10K Transistors (Very large —" —) (L)

ULSI → ⋮

SLSI → ⋮

Block diagram of a computer



Microprocessor

It is a semiconductor component designed by using VLSI Technology and it contains ALU, CU and Registers of a CP.U in a single package

NOTE- for a microprocessor memory is connected exeternally, the Resistors inside the processor can not be considered as memory, As they are used to hold the data temperarily. Latest processor may have some memory inside to store frequently used data or instruction

Ex. Cache memory

Bit → Binary digit

→ 0/1

⊥ Nibble → 4 Bits

⊥ Byte → 8 Bits

word length → depends on type of up

Word length

No. of Bits that can be processessed by a processor parallely at a line

Ex. 8 Bit µp → 8 bits (word length) / 1 Byte

16 Bit µp → 16 Bits / 2 Byte

32-" → → 4 Bytes

1971 → Intel 4004 → 4 Bit µp

1972 → Intel 8008 → 8 Bit µp

1974 → Intel 8080 → 8 Bits µp

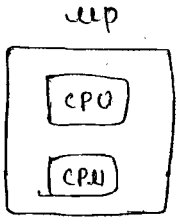
1977/78 → Intel 8085 → 8 Bit µp → Mate + IES

1979 → Intel 8086 → 16 Bit µp → IES

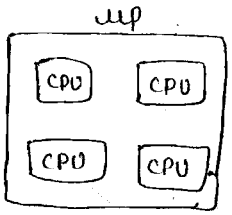
8088, 80186, 80286, 80386 [32 Bits]

PenHum ----- Dual core, ----- i_3, i_5, i_7 (64 Bit

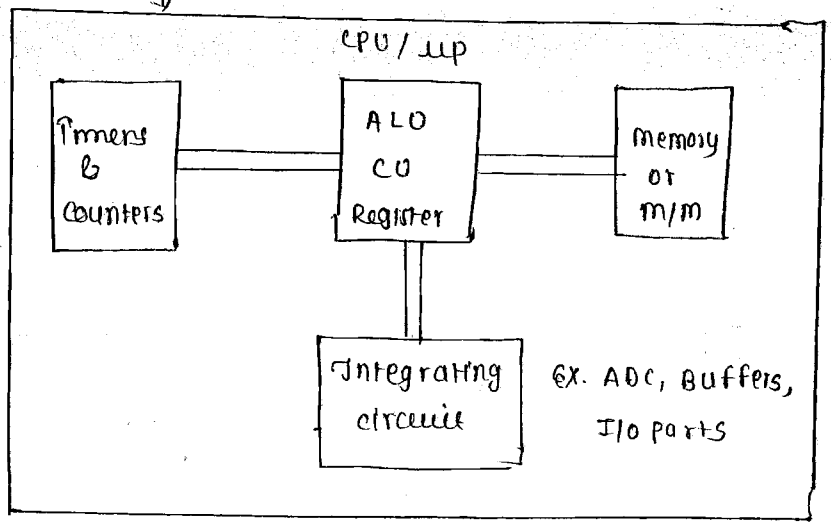
Dual core



Quad core



Micro controller

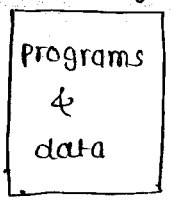
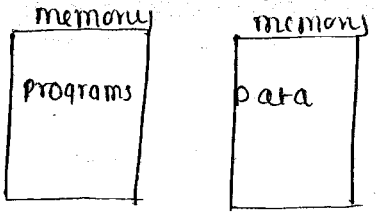


Microprocessor (µp)	Microcontroller (µC)
(1) It has ALU, CU, Register	(1) It has ALU, CU, Registers
(2) No Internal memory (m/m)	(2) has Internal /on-Board m/m
(3) No interfacing circuit's Timers / counters	(3) has interfacing circuit, Timers / counters
(4) used for general purpose application	(4) Used for specific purpose or application
(5) Ex. Intel 8085, iT, - mc 6800, Z-105 (Z80), AMD, Phillips, Toshiba, Qualcomm, national Semiconductors, Rockwell, fairchild	(5) Ex. TMS 1000 (4 Bit), Intel 8085 (8 Bit) Intel 80196 (16 Bit), PIC → 8 Bit & 16 Bit AT89C51, motorolla, phillips, Toshiba, Dallas semiconductors

Based on How programms and data are stored in the memory there are two types of Architecture

(1) Von-Neumann or princeton architecture

(2) Harvard Architecture

Von-Neumann or Princeton Architecture	Harvard Architecture
same memory for programme & data memory  Ex. Intel 8085 Intel 8086	seperate memory for programme & data (ROM) memory RAM memory  Ex. Intel 8051 (microcontroller)

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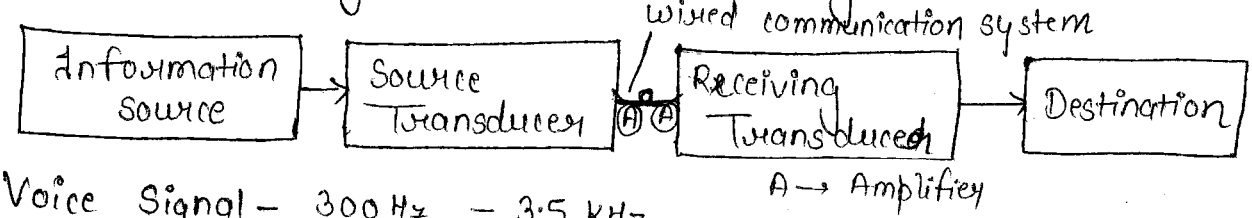
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Communication

"Communication is the process of transmitting information from one place to another."

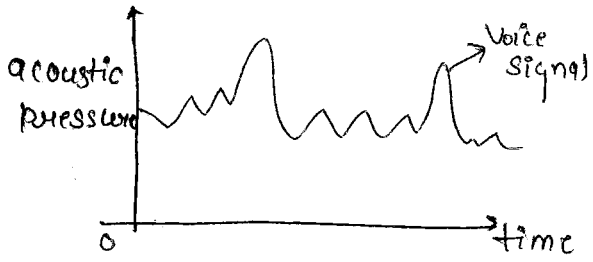
Basic block diagram of communication system:



Voice Signal – 300 Hz – 3.5 kHz

Audio Signal – 20 Hz – 20 kHz

Video Signal – 0 – 4.5 MHz



Source Transducer:

It converts physical signal into electrical equivalent.

e.g. – microphone

Wired communication system:

It is prefered only for short distance communication.

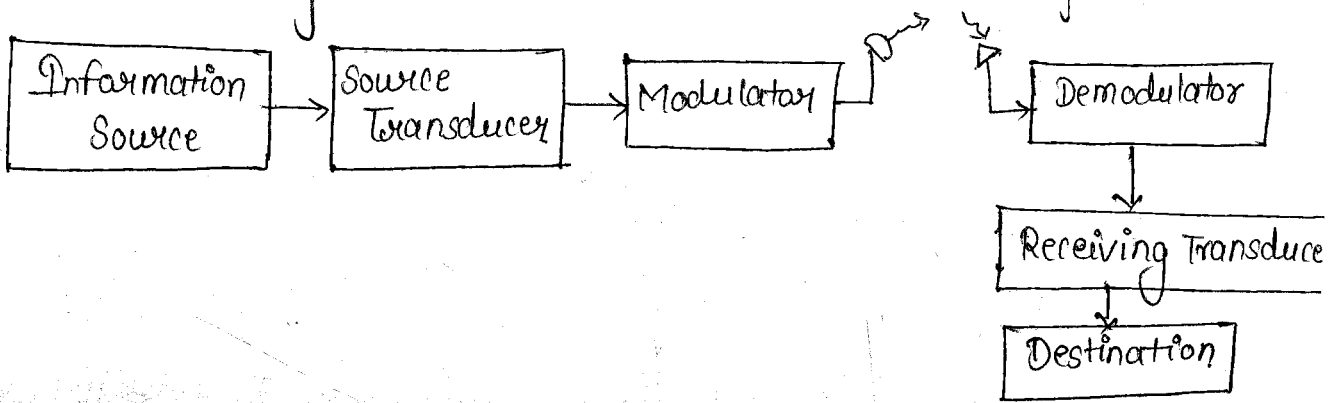
For long distance communication 'wireless Transmission' is preferred in which signal propagates through 'free space'.

Receiving Transducer:

It converts electrical signal into physical equivalent.

e.g. – loudspeaker.

Block Diagram of wireless communication system:



Generally without modulation long distance communication through free space is not possible.

Need for modulation -

1) Reducing antenna height :



$$h_t = \frac{\lambda}{4}$$

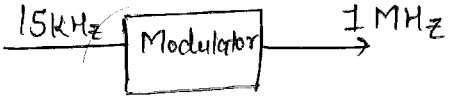
$$\lambda = \frac{v}{f} \qquad v = c$$

$$\lambda = \frac{c}{f}$$

$$h_t = \frac{c}{4f}$$

i) $f = 15\ KHz$

$$h_t = \frac{3 \times 10^8}{4 \times 15 \times 10^3} = 5\ Km$$ (Practically not possible to construct antenna with this height)

ii) 

$$h_t = \frac{3 \times 10^8}{4 \times 10^6} = 75\ m.$$ (Possible)

- For faithful radiation of a signal antenna height should be atleast of '$\lambda/4$'.
- Transmitting antenna converts electrical signal into electro magnetic, resulting propagates with light velocity.

NOTE -

Modulation is the process of increasing frequency of the signal to reduce antenna height requirements.

2) Multiplexing : It is the process of transmitting multiple number of signal through a single channel.

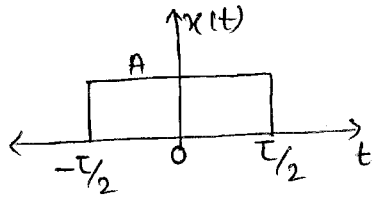
- Generally without modulation, multiplexing is not possible.

Fourier Transform:

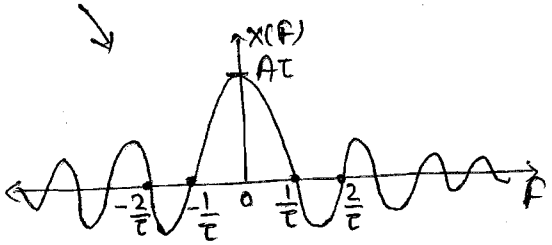
Fourier transform is basically used to find frequencies present in the given time domain signal.

$$x(t) \longrightarrow X(f)$$

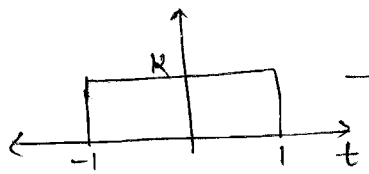
$$X(f) = \int_{-\infty}^{\infty} x(t)\, e^{-j2\pi ft}\, dt$$



$$X(f) = A\tau \,\text{sinc}(f\tau)$$



E.g.



$\longrightarrow 2K\,\text{Sinc}(2f)$

Signal Bandwidth = Highest +ve freq. − Lowest +ve freq.

Channel bandwidth ≥ Signal bandwidth.

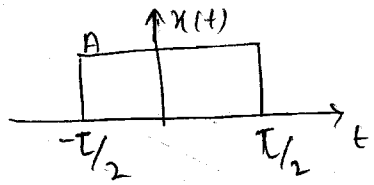
Channel standards -

Co-axial cable - 0 - 600 MHz

Parallel wire - 0 - 200 K

Fiber optic cable - GHz $= 10^9$ Hz $= 1000$ MHz

- For proper transmission of above signal, channel bandwidth of infinite is required but bandwidth offered by practical channel will be finite only so that before transmission it should be bandlimited by using 'Band Limiting Process'.



$$E = \int_{-\infty}^{\infty} x^2(t)\, dt = A^2\tau = \int_{-\infty}^{\infty} |X(f)|^2 df$$

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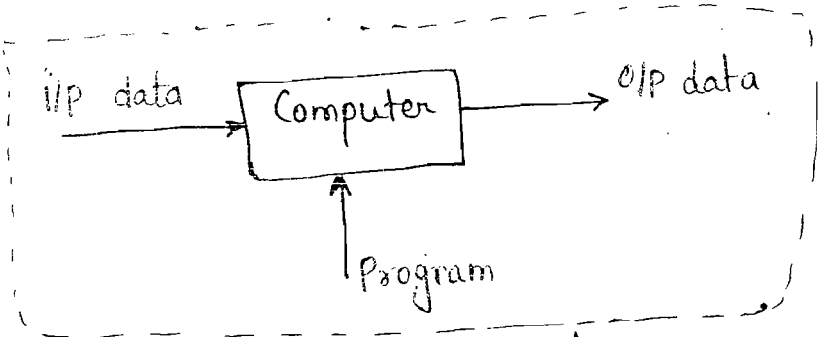
(1) Data Representation
(2) Computer Architecture
(3) Computer Organization
(4) OS concept
(5) Networking Concepts
(6) Programming ~~con~~ elements
(7) Data base Concepts

Chapter - 1

Data Representation

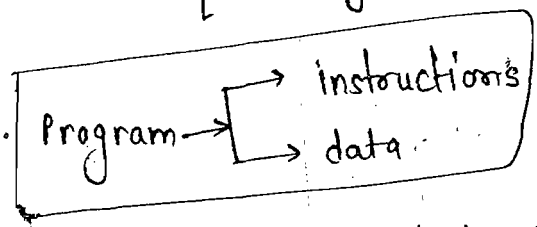
keywords

(1) Computer ⇒ it is a computational machine used to process the data under the control of a application program which is initiated by the user (or) programmer therefore computer system functionality is program execution.



Program Execution

(2) Program ⇒ Program is a sequence of instructions along with a data.



3) Instructions ⇒ It is a binary code which is designed inside the procesor to perform some task.

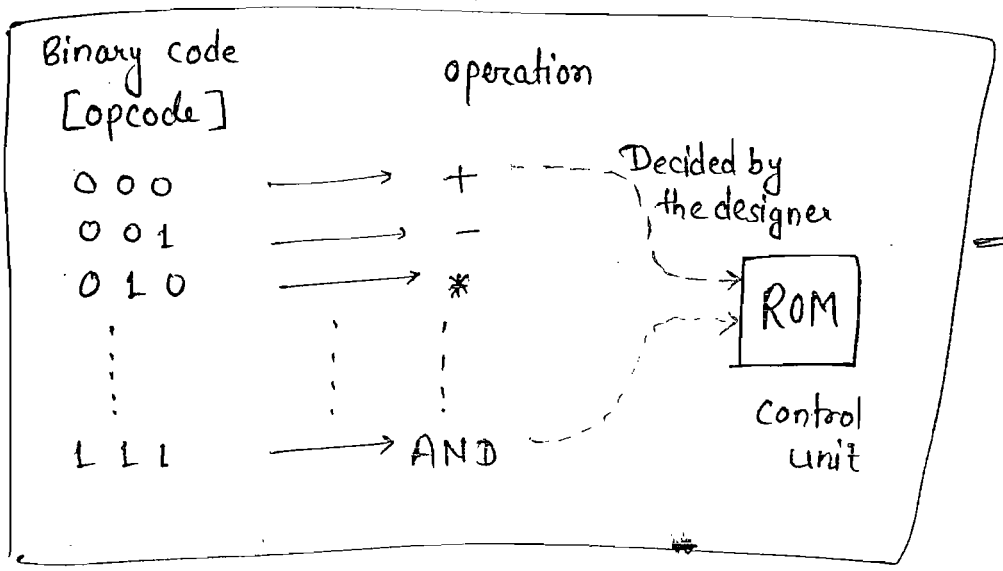
Binary code – Bind with – operation

Example:- Suppose CPU-X supports '8' ~~bit~~ different operation then

opcode size = $\log_2 8$ bit

= $\log_2 2^3$ bit

= 3 bit



⇒ Prepare the Istruction manual

(4) Design time ⇒

designer view

this flow diagram related to designer view

EE

Voltage

(5 – 2.5)V (0.5 – 0)

logic '1' logic '0'

EC

hardware chip

S_2 S_1 S_0

encoder { N: $\log_2 N$ bit }

Binary code

Hexa code

Low-level language → Assembly code

COA

CS

compiler

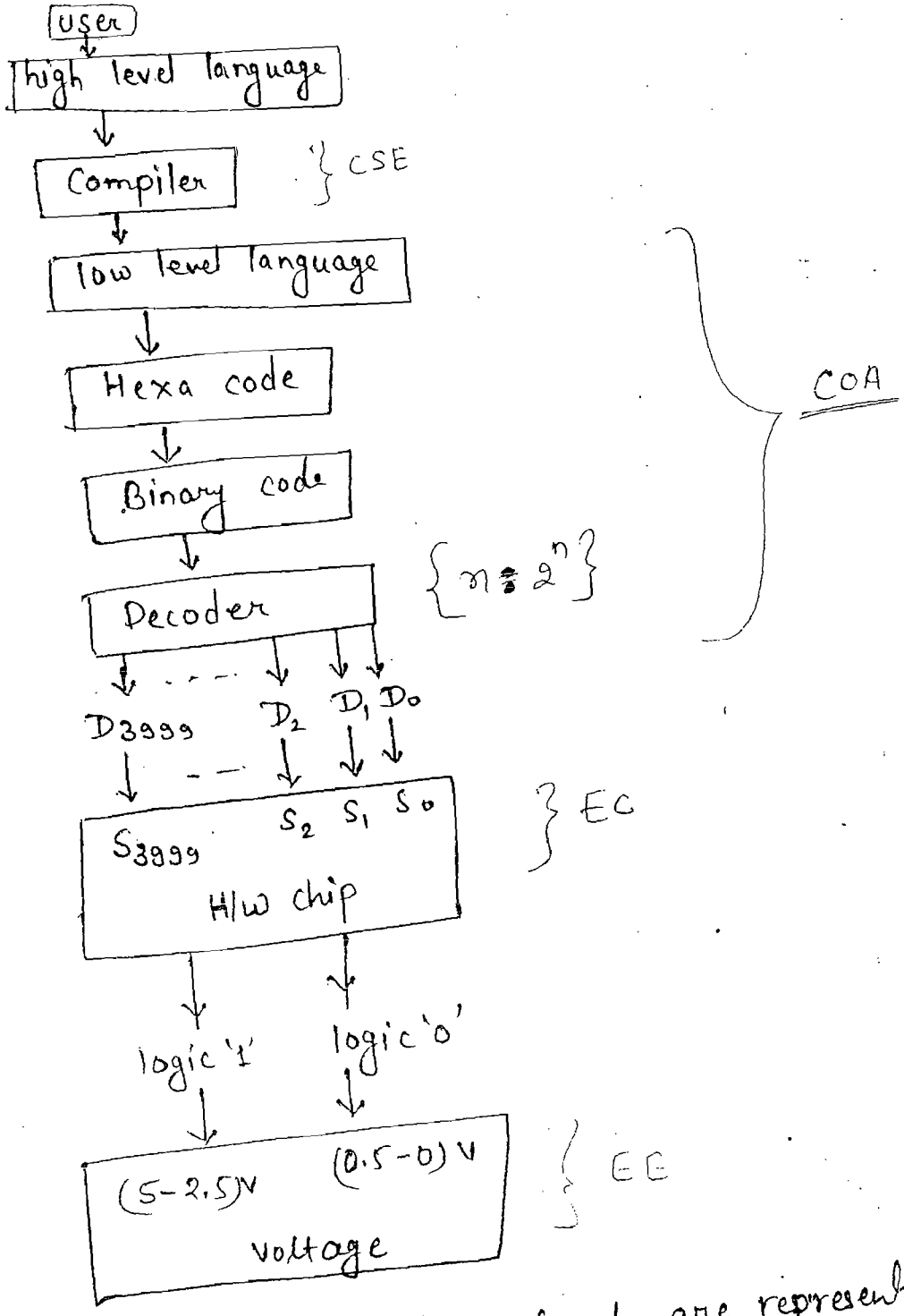
S/S & Software

High level language

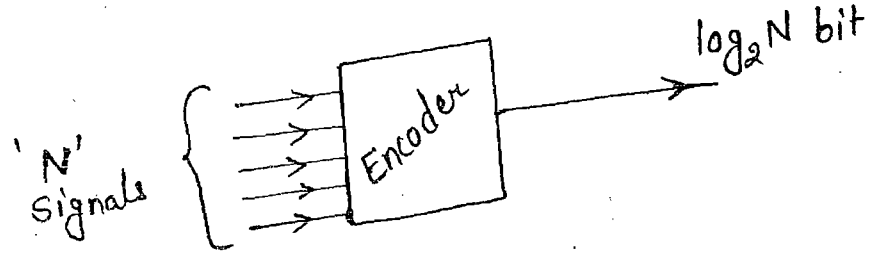
C code

User

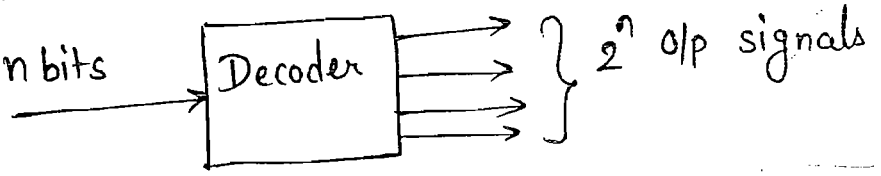
User view



5) Encoding :- In this process, 'N' signals are represented with $\log_2 N$ bit format.



Decoding :- In this process, n bit decoder produces 2^n o/p signals.



Data :- it is a binary code which is associated with a value based on the data format.

> Binary code — Bind with — Value

eg $(101)_2$: 5 , -1 , -2 , -3 , fraction

$(1\times2^2)+(0\times2^1)+(1\times2^0)$

$4+0+1$

5 ---- unsigned format (by default)

101 : -1 ---- sign magnitude format

101 : -2 ---- 1's complement format

101 → 010 (2)

101 : -3

101 → 010

+ 1

011 (3)

floating point format

2's complimet format

[Computer] — [user]

{Base=2} {Base=10}

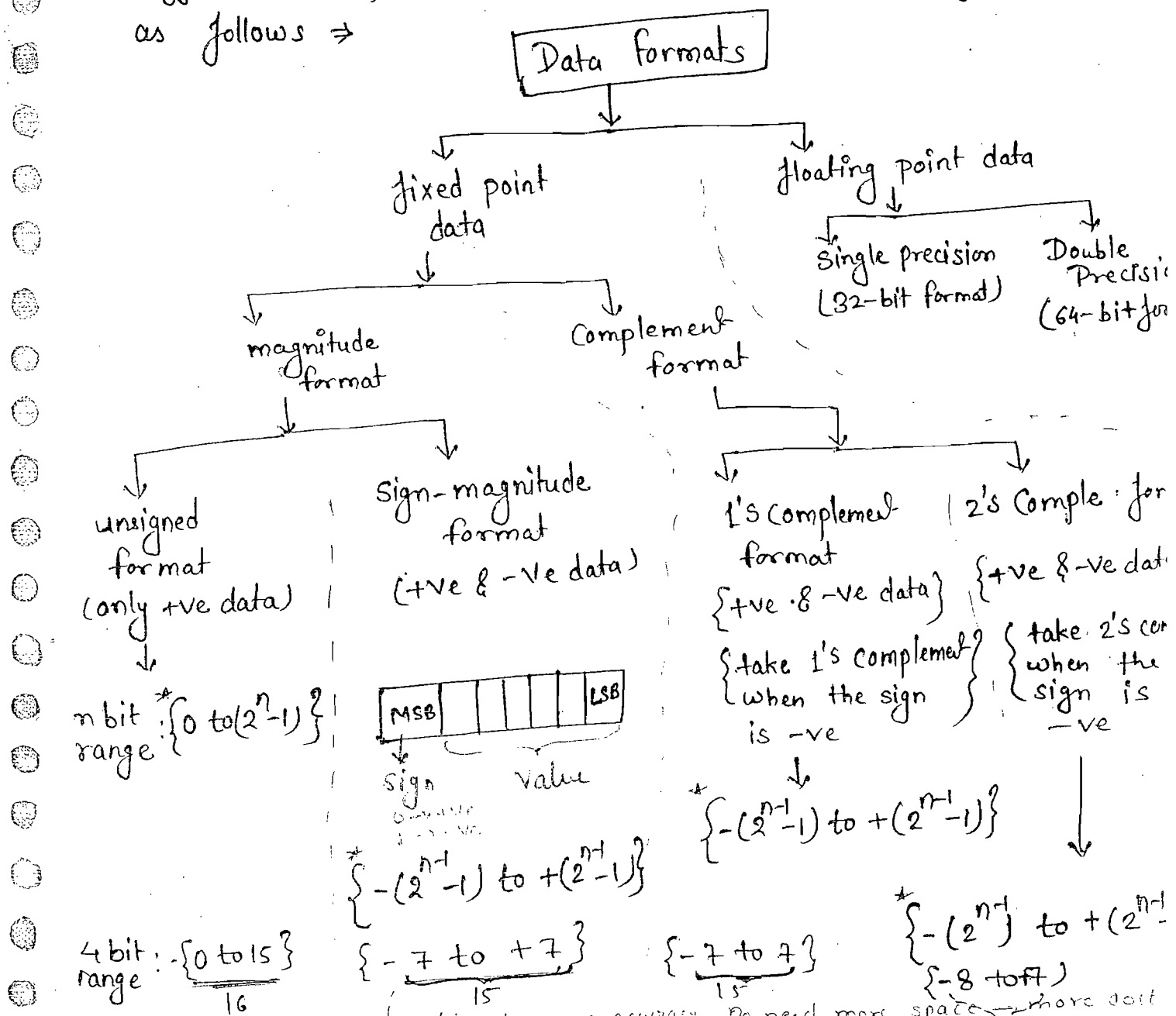
$(101)_2$ → ? Value → {5} data

$(101)_2$ → ? operation

↑

decided by designer

Different data formates used in the computer system is as follows ⇒



fixed-point data

n bit CPU :- word size = n bit
{Data size}

Eg → 4 bit CPU :- Data size = 4 bit

4 bit binary	unsigned Data	sign-magnitude Data	1's complement Data	2's complement Data
0000	0	+0	+0	+0
0001	1	+1	+1	+1
0010	2	+2	+2	+2
0011	3	+3	+3	+3
0100	4	+4	+4	+4
0101	5	+5	+5	+5
0110	6	+6	+6	+6
0111	7	+7	+7	+7
1000	8	-0	-7	-8
1001	9	-1	-6	-7
1010	10	-2	-5	-6
1011	11	-3	-4	-5
1100	12	-4	-3	-4
1101	13	-5	-2	-3
1110	14	-6	-1	-2
1111	15	-7	-0	-1

Same as sign-mgn for +ve

for 0000 → +{ }
0111
sign value

1000 → -{ }
1111
sign value

1000
-7
1000
0111
7

1001 → -6
1001 → 0110 = 6

1000 → -8
1000 → 0111
+1
1000
8

1001 → -7
1001 → 0110
+1
0111 = 7

Conclusion

Data type → data format

fixed point data →
- unsigned data (only +ve data) → unsigned format
- signed Data (+ve & -ve data) →
  - sign-magnitude format
  - 1's compl. format
  - 2's compl format

} Not in use (to contain 2 possible codes)

So **bydefault signed data is 2's compl data**

Note: **2's complement of "N" & "−N"**

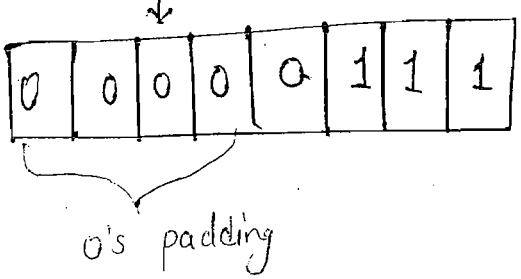
eg 2's compl of '5' & '−5'

4 bit code

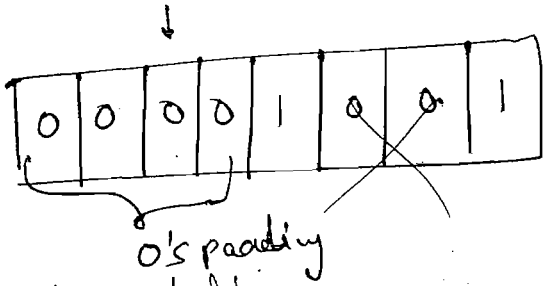
5 : 0101
↓ 2's compli
1010
+ 1
−5 ← 1011

7 : 0111
↓ 2's comp
1000
+ 1
−7 ← 1001

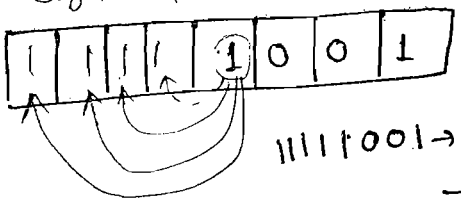
unsigned data
↓
7 : 0111
↓ stored in 8 bit register



signed data
↓
−7 : 1001
↓ stored in 8 bit regist



sign extention



11111001 → 00000
+
00001

Q) Consider the following binary code 10001010 what is its decimal equivalent when the data is in

(1) Unsigned
(2) Sign - magnitude
(3) 1's compl
(4) 2's comple format

Soln

binary code → $2^7\ 2^6\ 2^5\ 2^4\ 2^3\ 2^2\ 2^1\ 2^0$
1000 1010

8 x 8 x 2
64 x 2
128

(i) unsigned : $= (1\times2^7) + (1\times2^3) + (1\times2^1)$

$= 128 + 8 + 2$

$= 138$

(ii) sign - magnitude = 1 000 1010
8+2
(10)
↓
−10

iii) 1's complement of 1000 1010 : (−117)

1's 1000 1010
0111 0101
$2^6\ 2^5\ 2^4\ 2^3\ 2^2\ 2^1\ 2^0 \rightarrow 2^6+2^5+2^4+2^2+1 = 117$

iv) 2's complement of 1000 1010 : (−118)

1000 1010
0111 0101
+ 1
0111 0110
$2^6+2^5+2^4+2^2+2^1 = 118$

Q) which of the following codes are redundent codes in the CPU using sign - magnitude & 1's comp format.

(i) 00 & AF
(ii) 80 & 80
(iii) 00 & FF
(iv) 00 & CF

Soln

Sign magnitude:
0000 0000 : +0
1000 0000 : −0

1's compliment:
0000 0000 : +0
1111 1111 : −0