MADE EASY

Electrical Engineering

Toppers Handwritten Notes

Network Theory

By-Aditya Sir

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

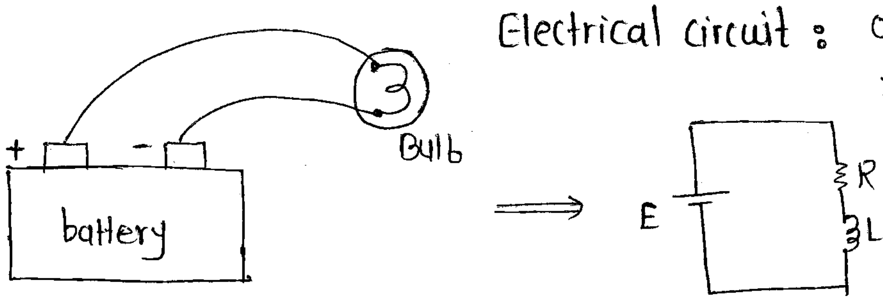
③ Theorems :
- superposition
- Thevenin
- Nortons
- Maximum power Transfer

Gate

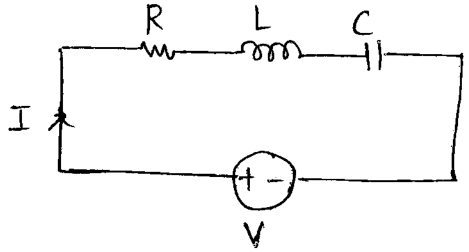
- Reciprocity
- Millman's
- compensation
- substitution
- Tellegen's theorem

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 : <u>Charge</u>

⊙ **Charge :** • charge is the electrical Property of the atomic Partical of which the Matter Consist of. (C)

• [Electrical Property → Atomic Particles → Matter]

Charge on $\boxed{1 e^- : -1.6 \times 10^{-19} C}$

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)

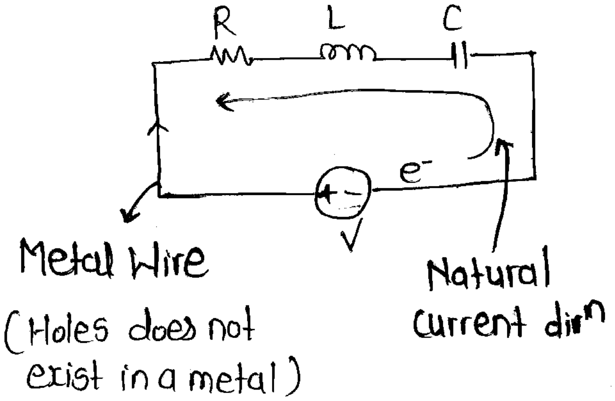
$$\boxed{I_{av} = \frac{\Delta q}{\Delta t}} \quad C/s \text{ or } Amp.$$

- 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 :



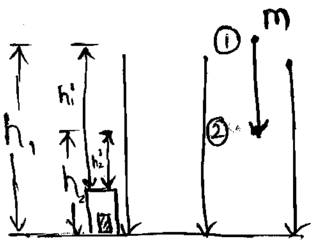
Conventionally, ---> the current direction is taken in the direction of the positive charge moment.

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

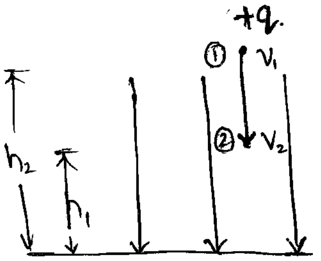
$$\boxed{E = V = \frac{dW}{dt}} \quad J/C \text{ or } V$$

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



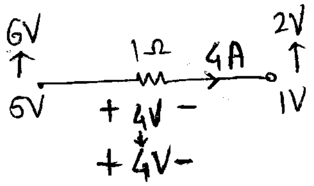
Energy gained by the mass in moving from pt. ① to ②:

$$= \underbrace{mg(h_1-h_2)}_{\text{gravitational potential diff.}}$$

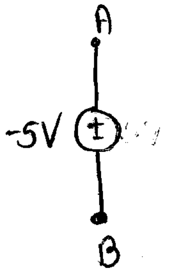


Energy gained by the charge in moving from pt ① to ②:

$$= \underbrace{q(V_1-V_2)}_{\text{Electrical potential difference.}}$$

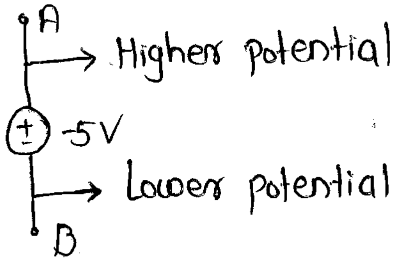


Que:



ⓐ $V_A > V_B$
ⓑ $A_A = V_B$
ⓒ $V_A < V_B$
ⓓ Cant comment

Solⁿ:



Higher Pot. − Lower Pot. = −5 V

$V_A - V_B = -5\,V$

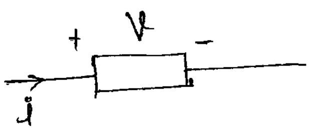
$V_A = V_B - 5$

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

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

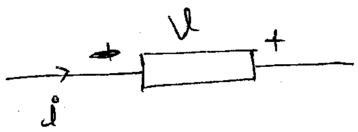
$$P = \frac{dW}{dq} \cdot \frac{dq}{dt}$$

$$\boxed{P(t) = v(t) \cdot i(t)}$$



$P = +Vi$

ⓐ



$P = -Vi$

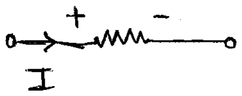
ⓑ

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

fig. ⓐ Power absorbed or Power received or power dissipated	Fig. ⓑ 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

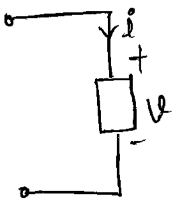
② And when the current leaves from the +ve terminal or current enter into the -ve terminal, then the element delivers the power.



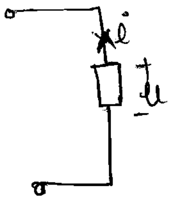
Power absorbed

Power delivered

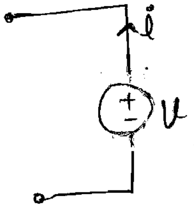
- Hence, for determine Sign of the power, The voltage polarity & the c/n direction are important.



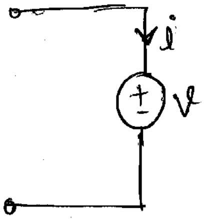
Power abso.
∴ Load



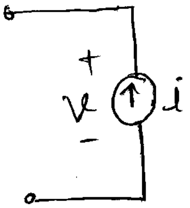
Power deli.
∴ Source



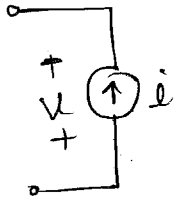
Power deli.
∴ Source



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.

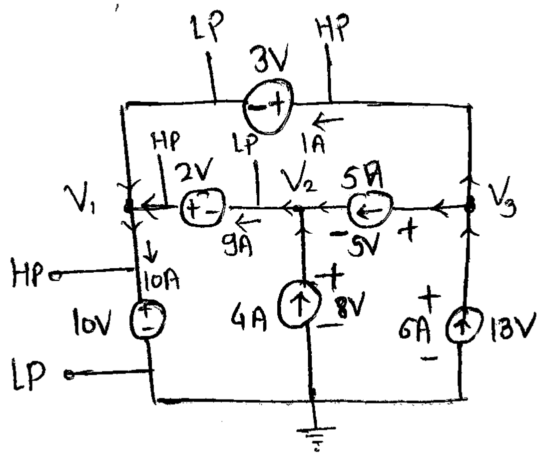
∴ In Any Electrical Circuit :

$$\Sigma P = 0$$

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

- 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:

$V_1 - 0 = 10V$

$V_1 = 10V$

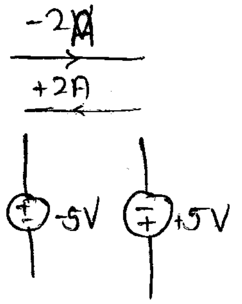
$V_1 - V_2 = 2V$

$-V_2 = 2 - 10$

$V_2 = 8V$

$V_3 - V_1 = 3V$

$V_3 = 13V$



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

$= -32\,W$

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

$= 25\,W$

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

$= -78\,W$

- 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)

$= 128\,W$

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

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^-

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

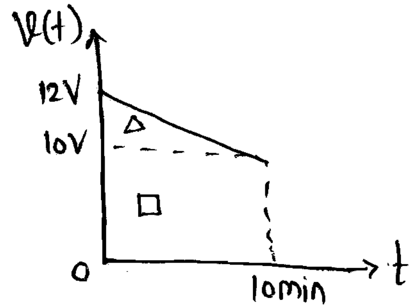
⑤ **Energy** : It is the capacity or ability to do the work. (J or Watt-sec)

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

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

Gate 2009

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.



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

$= \int_0^t v(t).\,i(t).\,dt$

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

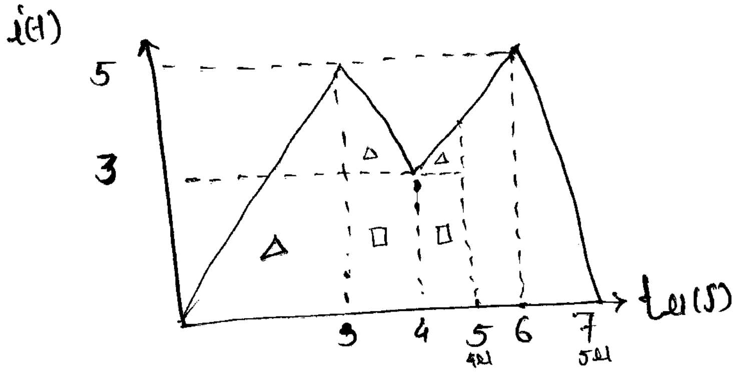
$= 2\left[\left(\frac{1}{2}\times 10min \times (12-10)\right) + (10\times 10)\right].60$

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

$= 2\times 6600$

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

Que. A c/n i(t) as shown in the fig. is passed thr a capacitor. A charge in μC aquire by the capʳ in 5μs. will be ---



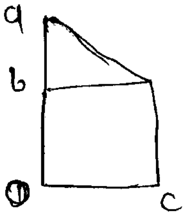
Sol^n: $i(t) = \frac{dq}{dt}$

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

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

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

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



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

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

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

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

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

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

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

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

$$\boxed{q = 15\mu C}$$

que: ckt 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.

Sol^n: Given;

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

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

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

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

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

$$= 36 + 15$$

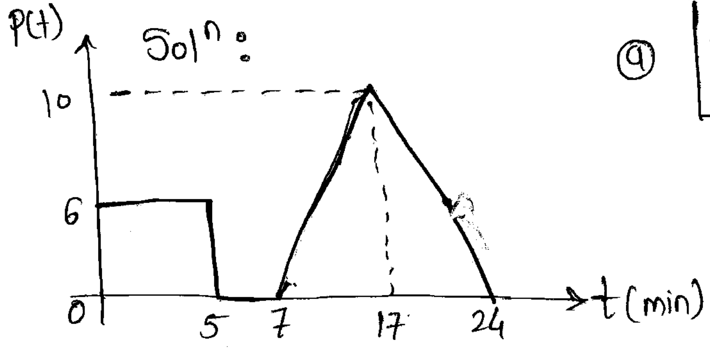
$$\boxed{q(t) = 51C}$$

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 10 W for the next 10 min. and a power that decreases linearly from 10 W to 0 in the following 7 min.

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

ⓑ What is the avg. Power in Watt during this time.

Sol^n:



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

$$= [6\times5] + [\tfrac{1}{2}\times10\times10] + [\tfrac{1}{2}\times10\times7]$$

$$= [30 + 50 + 35]\times60$$

$$= (115\times60)$$

$$W = 6900\,J$$

EMFT [Himadri Shekhar]

-: 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 (ρ, 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

$\hat{a}_\rho \cdot \hat{a}_\rho = 1$; 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.

$\hat{a}_\rho \cdot \hat{a}_\varphi = 0$; 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 vector of same co-ordinates system results to third unit vector which is mutually perpendicular to the initial vectors

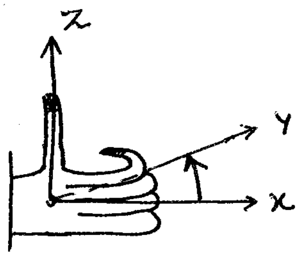
Ex:- $\hat{a_x} \times \hat{a_y} = \hat{a_z}$; ca.co.syst.

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

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

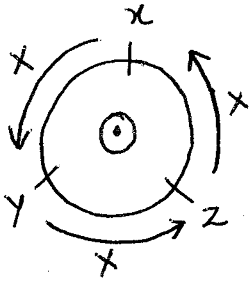
(iii) the direction of 3rd unit vector is found using R-H curl rule.

Ex:-

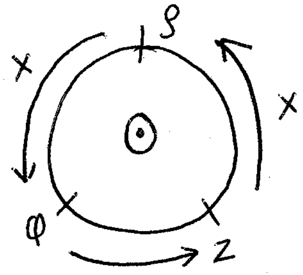


R-H curl Thumb
x ↷ y z

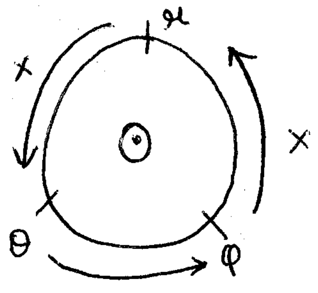
⊙ ≡ out of plane
⊗ ≡ into the plane



-: ca.co.system:-

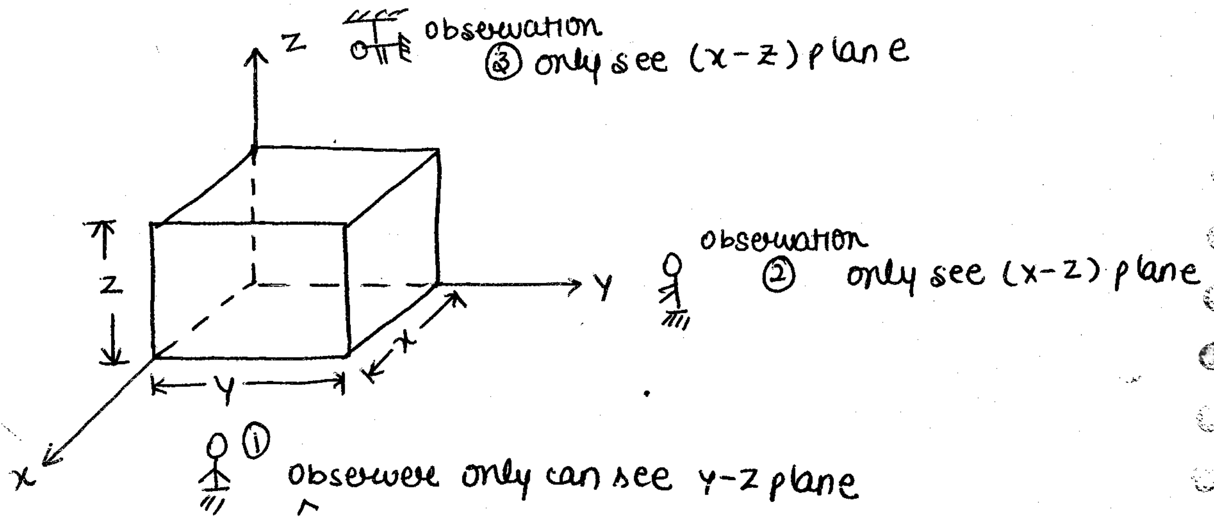


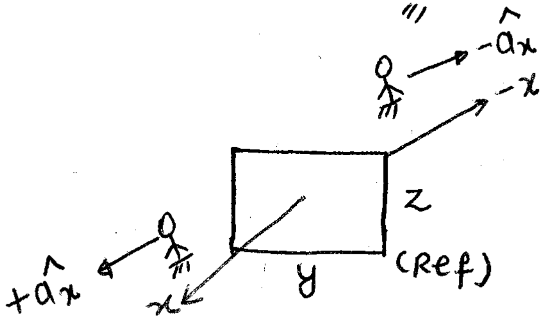
-: cy.co.system:-



-: sp.co.system:-

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

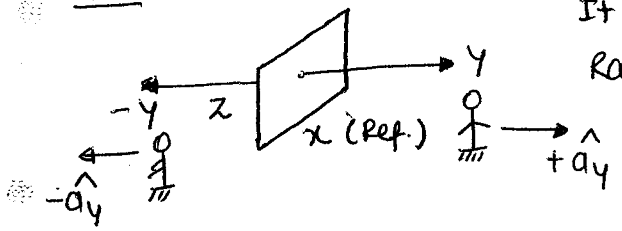




x :- Perpendicular distance from yz plane

Range : (∞, -∞)

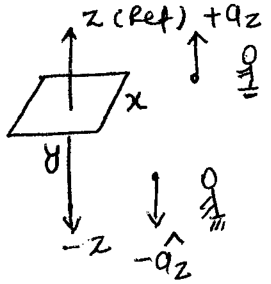
Y :-



It is perpendicular distance from (x-z) plane

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

Z :-

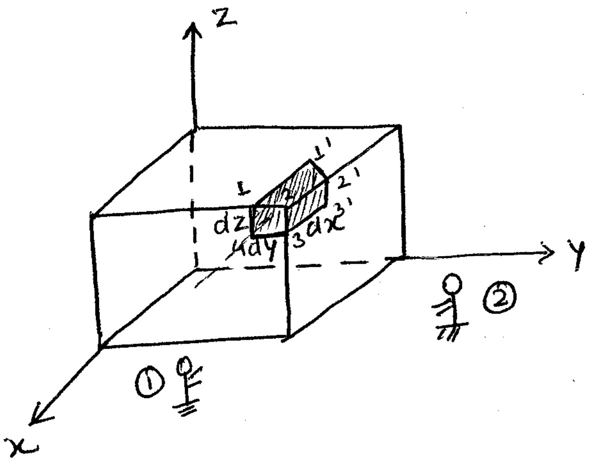


It is perpendicular distance from (x-y) plane.

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

concept of differential length, Area and volume :-

Graphical approach :-



Differential length dl :-

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

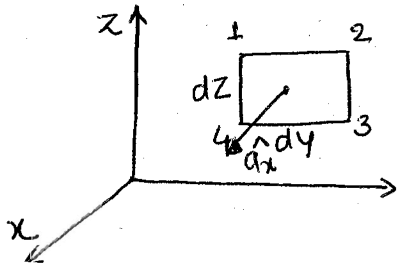
Differential length along y-axis = $dy\,\hat{a}_y$

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

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

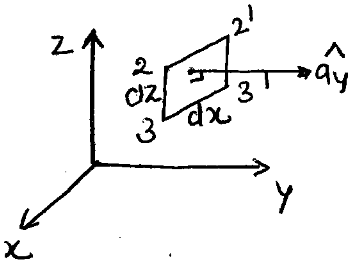
Differential surface area ds :-

observer ①



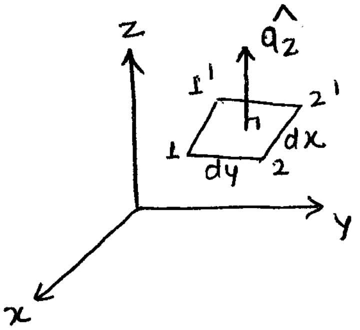
$$\boxed{\vec{ds} = dy\,dz\,\hat{a}_x}$$

Observer ②



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

Observer ③



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

where area vector are $\hat{a}_x$, $\hat{d}_y$, $\hat{a}_z$. 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):-

$$\boxed{dv = dx\,dy\,dz}$$

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

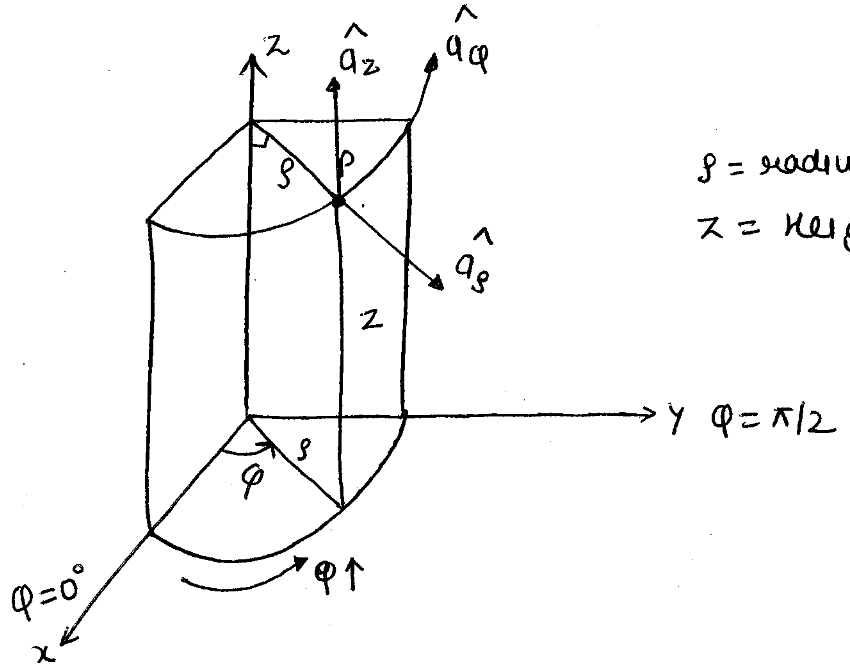
$$dl = dx\,\hat{a}_x + dy\,\hat{d}_y + dz\,\hat{d}_z$$

$$ds = 1 \times 1 \times dy\,dz\,\hat{a}_x$$ [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

$\bar{A_P} = A_u \hat{a_u} + A_v \hat{a_v} + A_w \hat{a_w}$; u, v, w = parameter

$\bar{A_P} = A_\rho \hat{a_\rho} + A_\varphi \hat{a_\varphi} + A_z \hat{a_z}$

→ $\boxed{\rho}$: It is the perpendicular distance from reference axis {z-axis}

Range of ρ : $[0, \infty)$

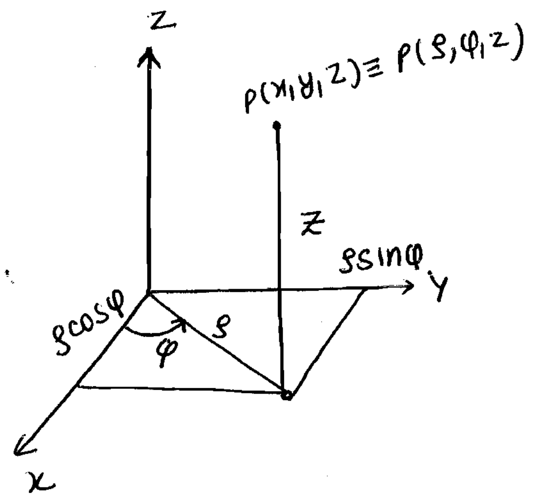
→ $\boxed{\varphi}$: orientation angle of point about z-axis and is always measured with respect to x-axis i.e, @ x-axis, $\varphi = 0°$ [Also known as azimuthal angle]

Range of φ : $[0, 2\pi]$

→ $\boxed{z}$: It is Height of point along z-axis.

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

elation between carterian coordinate system and cylindrical co-ordinate system :-



(i) In terms of parameters :

$$\boxed{x = \rho\cos\varphi}$$
$$\boxed{y = \rho\sin\varphi}$$
$$\boxed{z = z}$$

Now ;

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

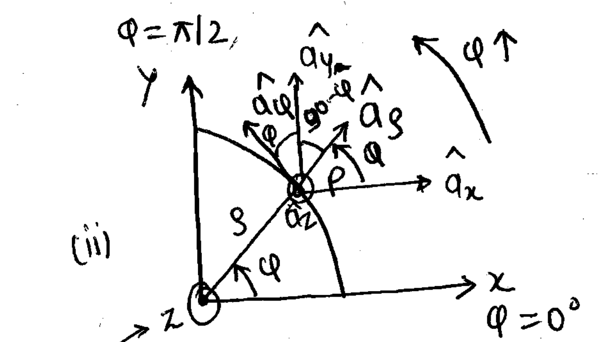
$$x^2 + y^2 = \rho^2$$

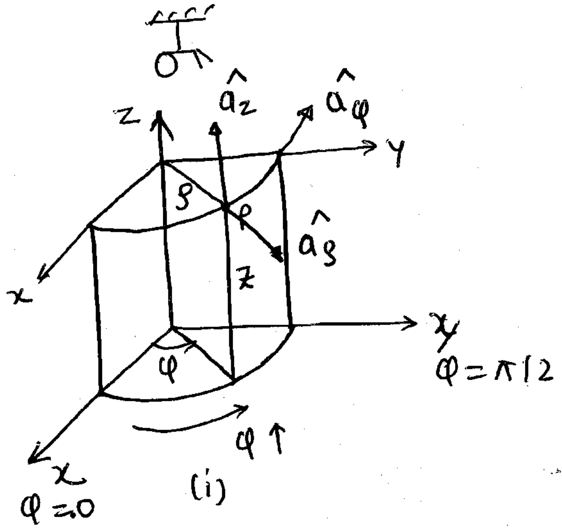
$$\boxed{\rho = \sqrt{x^2+y^2}}$$

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 :-

$a_\rho \wedge a_\varphi = 90°$

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

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

$\underset{\downarrow\,90°}{\hat{a}_\rho \cdot \hat{a}_z} = 0$

$\overset{90+\varphi}{\uparrow}$

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

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

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

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

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

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

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03.DIGITAL ELECTRONICS

BY- RAMESH SIR

Introduction

#Boolean Logical Ideas—

These are categorized into 3 ways—

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

Note. For n 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

→ $\textcircled{f_0} = 0$ $\boxed{\text{Null}}$

→ $\textcircled{f_1} = x \cdot y$ $\boxed{\text{AND}}$

$x \cap y$

→ $\textcircled{f_2} = x \cdot \overline{y}$ $\boxed{\text{Inhibition}}$

x / y [x but not y]

→ $\textcircled{f_3} = x$ $\boxed{\text{transfer [Buffer]}}$

→ $\textcircled{f_4} = \overline{x} \cdot y$ $\boxed{\text{Inhibition}}$

y / x [y but not x]

→ $\textcircled{f_5} = y$ $\boxed{\text{Buffer}}$

→ $\textcircled{f_6} = x \oplus y$ $\boxed{\text{Ex-OR}}$

$= \overline{x} y + x \overline{y}$

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.

→ $\textcircled{f_7} = x + y$ $\boxed{\text{OR}}$

$x \cup y$

→ $\textcircled{f_8} = \overline{x + y}$ $\boxed{\text{NOR}}$

$x \downarrow y$

→ $f_9 = x \odot y$ Ex-NOR

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

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

→ $f_{10} = \bar{y}$ NOT

→ $f_{11} = x + \bar{y}$ Implication

→ $f_{12} = \bar{x}$ NOT

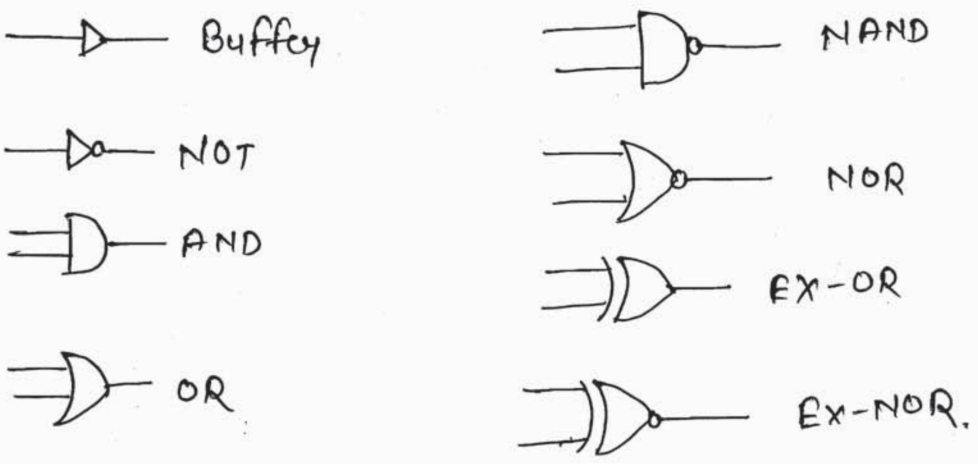
→ $f_{13} = \bar{x} + y$ Implication

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

$x \uparrow y$

→ $f_{15} = 1$ Identity

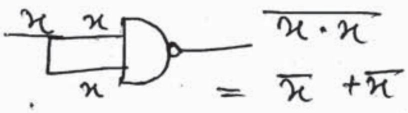
Logic Gate Symbols



→ 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 $\xrightleftharpoons{4}$	NOR
NOT	1	1
AND	2	3
OR	3	2
EX-OR	4	5
EX-NOR	5	4

Duality

Step-1 Interchange the operator → $(\cdot , +)$

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) $x \cdot 0 = 0$

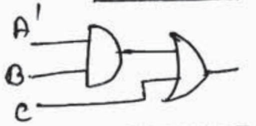
$x + 1 = 1$

ii) $F = A'B + C$

$F^D = ?$

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

AND-OR

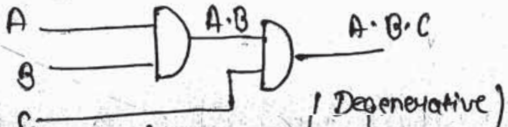


OR-AND

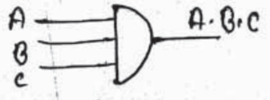
Degenerative forms

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.

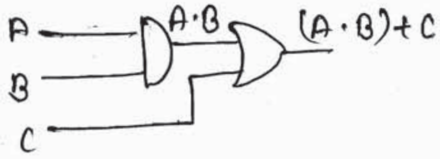


AND – AND (Degenerative form)



AND

(~~Degenr~~



Non-degenerative form.

*** Shortcut**

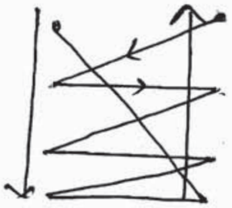
AND — OR　　OR — AND

NAND — NAND

NOR — OR　　NOR — NOR

　　　　　　NAND — AND

OR — NAND　　AND — NOR

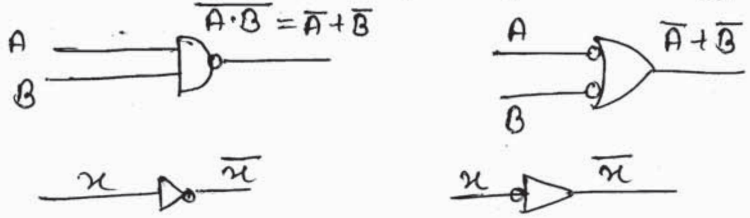


These are non-degenerative forms.

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

Alternative logic gate ~~getting~~

E.g.



*** Shortcut**

NAND $\xrightarrow{\text{bubbled}}$ OR

NOR $\longrightarrow$ AND

AND $\longrightarrow$ NOR

OR $\longrightarrow$ NAND

Complimenting a boolean expression

1 - Dual form

2 - Complimenting the individual variable.

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

$\overline{F} = ?$

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

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

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04.CONTROL SYSTEM

BY- HANEEF SIR

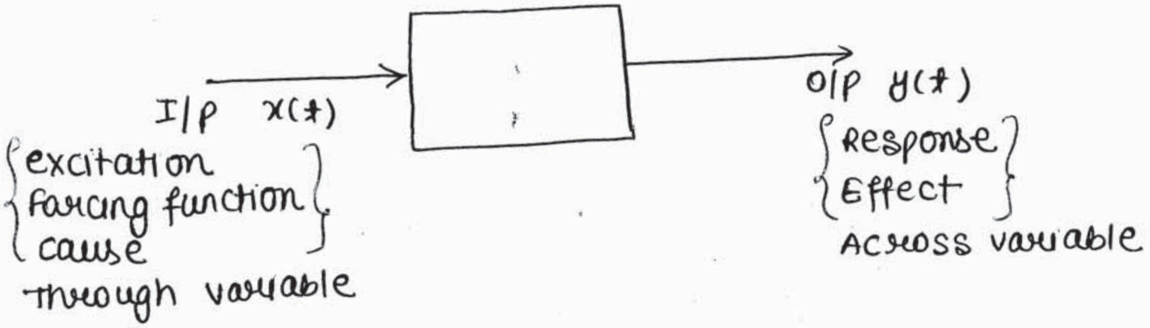
System :- The means of transfarming a signal.

Signal is a farm of energy that contains infarmation of some phenomenon. Mathematically, signal can be defined as one are mare number of independent variables.

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

Image = f(x, y)

video = f(x, y, t)



$$\boxed{y(t) = T[x(t)]}$$

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

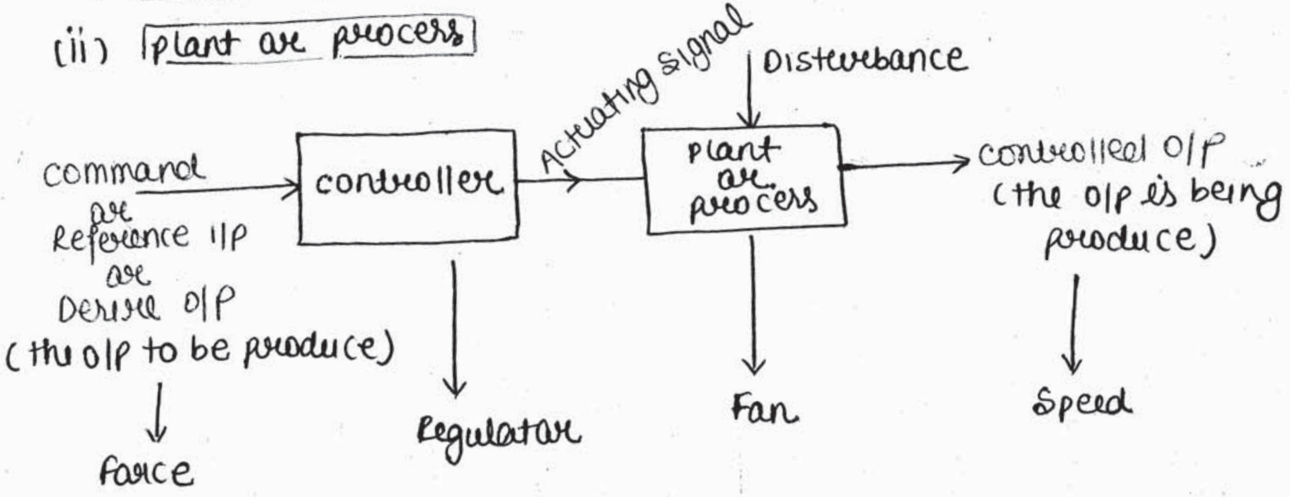
Ex-: system : J/K F/F

Master slave F/F : control system

To make control system we need basically two element -

(i) controller

(ii) plant are process



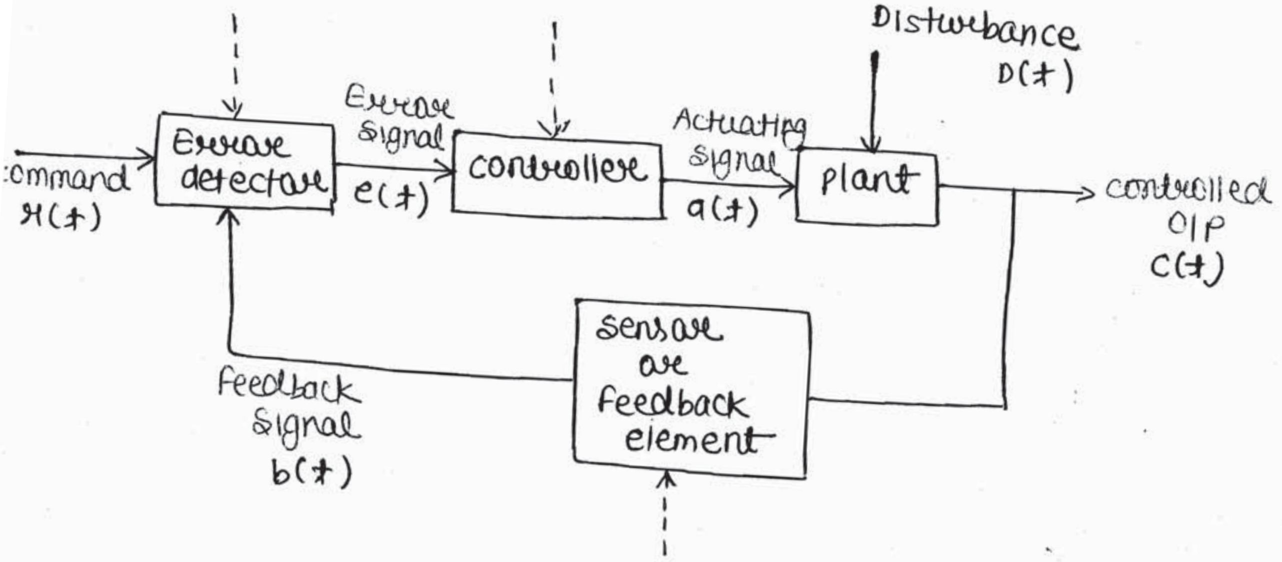
SISO :- MISO -:

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 :-



$\boxed{C(t) = C_R(t) + C_D(t)}$ [Linear combination because r(t) & D(t) both are independent to each other]

$\boxed{\text{Disturbation} = \text{Distortion} + \text{Noise}}$

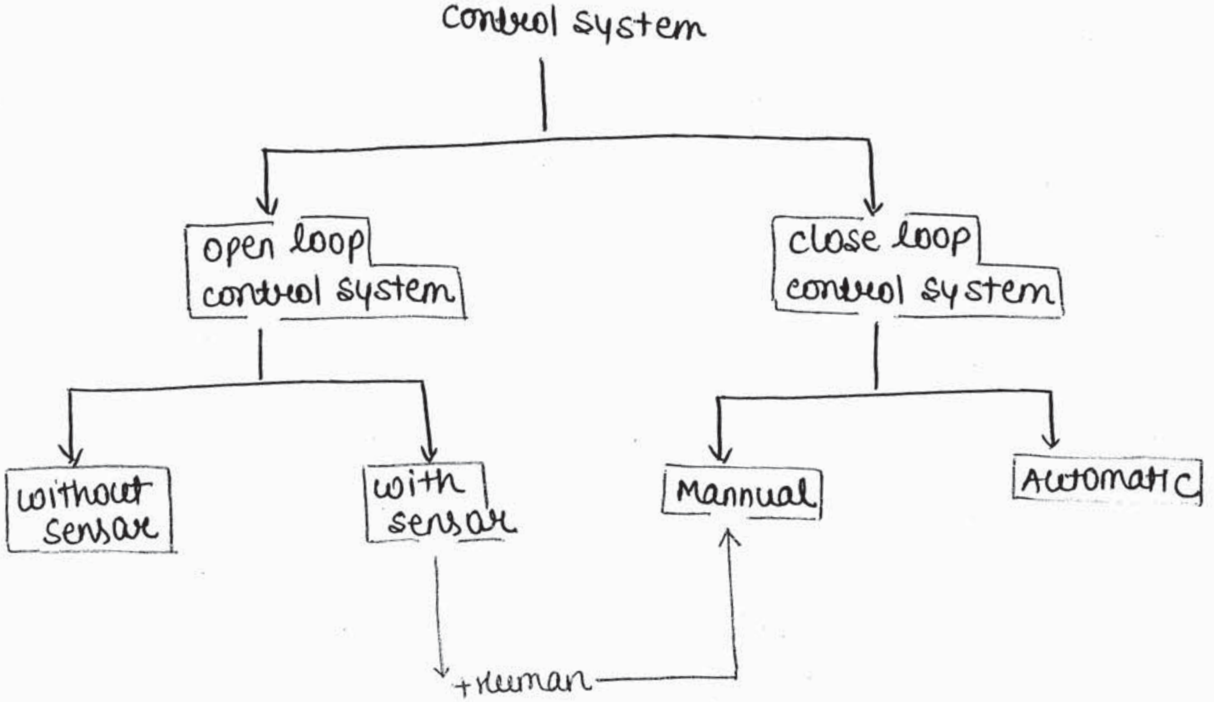
Distortion ↓ Internal disturbance

Noise ↓ 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.

$+10 = 10\angle 0°$ → +ve feedback i.e; in phase

$-10\,V = 10\angle 180°$ → -ve feedback i.e; out of phase control system is classified into two categaries-



Differences between open loop and close loop system :-

open loop control system	close loop control system
(i) The behaviour of OLTS 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 sensore 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 stablized.
(vi) OLCS is simple & economical	(vi) CLCS is complex & expensive.

NOTE-: (i) The transient in system are due to stared 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/ compensatare preferably P+D controller/ lead compenratar.

Ste

(iii) A system can be stable ore unstable are 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 transpartain delay or lag phase.

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

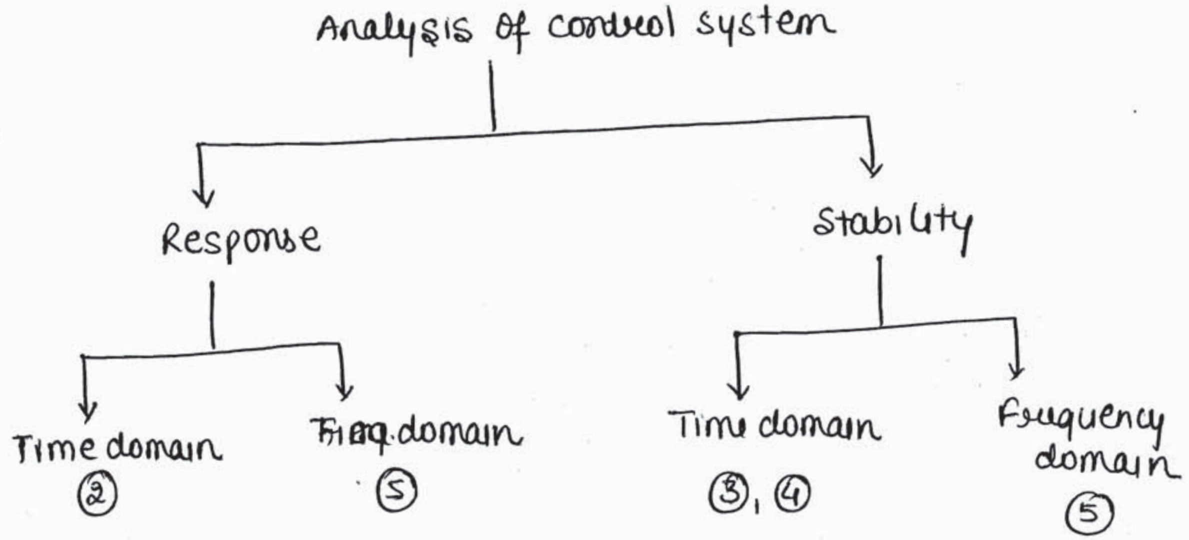
parameter	$1\angle 180^\circ$ -ve F.B.	$1\angle 0^\circ$ +ve F.B.
Gain	↓	↑
Bandwidth	↑	↓
Time constant	↓	↑
Speed	↑	↓
sensitivity	↓	↑
stability	↑	↓

Gain x Bandwidth = constant   Time constant x speed = constant

sensitivity x stability = constant

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

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.

$$\boxed{T.f. = \frac{L[O/P]}{L[I/P]}}\Bigg|_{\text{initial condition} = 0}$$

$$\boxed{\text{Total response} = \underbrace{\cancelto{0}{ZIR}}_{\text{due to initial condition/state}} + \underbrace{ZSR}_{\text{due to i/p}}}$$

ZIR - zero i/p response
i.e; i/p = 0

ZSR - zero state response

$$Y = c + \underbrace{mx}_{\text{due to i/p because x is a part of it.}}$$

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

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

$$\boxed{T.F. = L[IR] = S\,L[SR] = S^2 L[RR] = S^3 L[PR]}$$

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

Solution:- $T.F. = S\,L[SR]$

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

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

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

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

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

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

$T.F. = L[IR]$

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

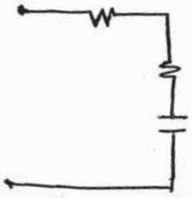
$$SR = (1-10e^{-t})\,u(t)$$

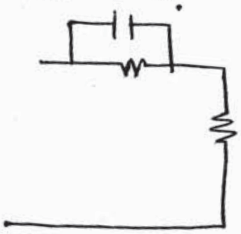
$$RR = \int_0^t (SR)\,dt = \int_0^t (1-10e^{-t})\,u(t) =$$

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

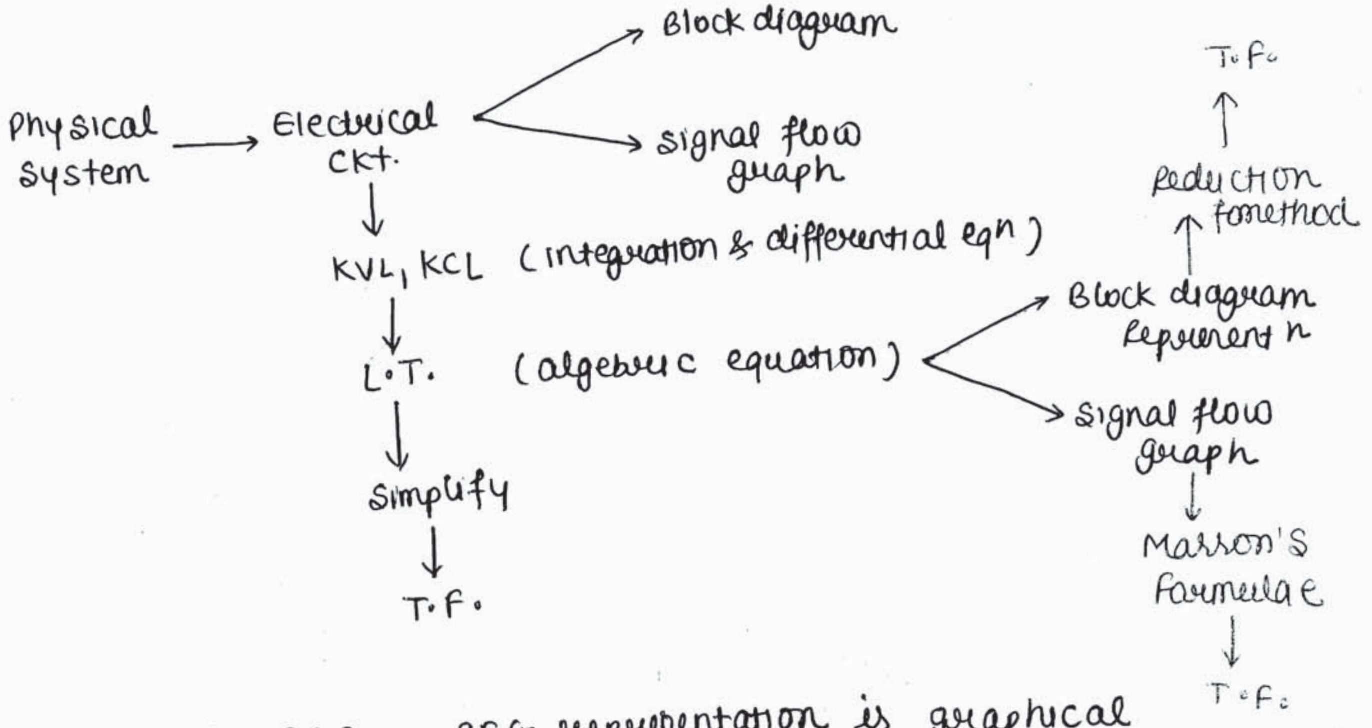
if $\boxed{\text{initial condition}}$ is $\boxed{\text{zero}}$ then $\boxed{L\,[\text{Impulse response}] = T.F.}$

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





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



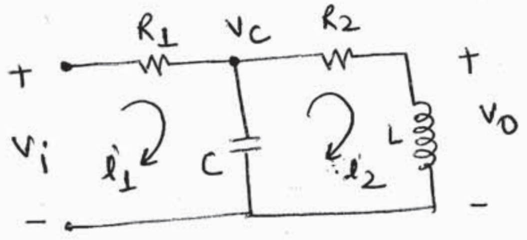
BDR, SFG: BDR or SFG representation is graphical representation of mathematical relation between the variables of a system described in the form of set of linear algebric equation in cause effect form.

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

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

$q = Cv$

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



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

not in cause effect form $\Leftarrow$ $V_i = \cancel{i_1 R_1 + \frac{1}{C}} \int (i_1 - i_2)\, dt$ $V_0 = (SL) i_2$

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

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

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05.SIGNAL & SYSTEM

BY- ROHIT TRIPATHI SIR

Chapters :-

1. signals definition and its classification
   - → Even / Odd
   - → Periodic / Non-periodic
   - → Cajugate symmetric & conjugate antisymmetri
   - → Half wave symmetry
   - → Energy and Power signd

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

Basic system properties
   - → static / dynamic system
   - → Linear / non-linear
   - → causal / Non-causal
   - → stable / unstable
   - → Time invarient / Time-varient
   - → Invertiable / Non-invertible

Fourier Series (continuous time)

Fourier Transform (continuous time)

Laplace Transform

Sampling Theorem

Discrete time signal & system
   - → Types of signals
   - → Basic signals
   - → Different operations on signal
   - → Types of systems

9. Z-Transform $\longrightarrow$ GATE + IES

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

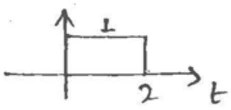
11. Digital filters
    - → Infinite impulse response (IIR) filter
    - → finite impulse response (FIR) filter
    - → Impulse invarience method
    - → Bilinear transformation method

12. Discrete cosine transform (DCT)
$\longrightarrow$ IES only.

II. Different operations on signal :-

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

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



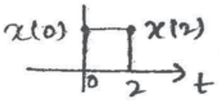
Case (i) :- When $k>0$ (Left shifting) :-

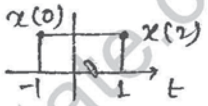
Example $k=1$

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

$t=-1$ .. $x(0)$

$t=1$ $x(2)$





(Left shifting)

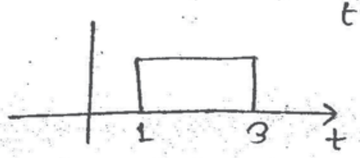
Case (ii) :- When $k<0$ (Right shifting) :-

Example $k=-1$

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

$t=1$ $x(0)$

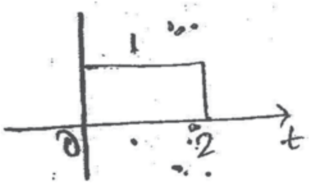
$t=3$ $x(2)$



(Right shifting)

(2) **Amplitude shifting** :-
- upward
- downward

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



Case (i) <u>When $K>0$</u> (upward shifting)

Example $k=1$

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

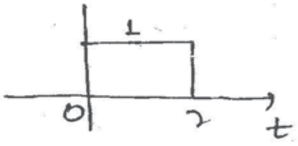
$$x(t) = \begin{cases} 0 \;; & t<0 \\ 1 \;; & 0\le t\le 2 \\ 0 \;; & t>2 \end{cases}$$

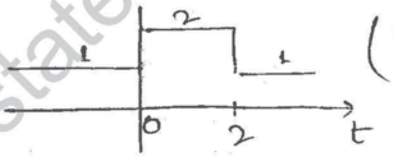
$$y(t) = 1+x(t)$$

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

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

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





(upward shifting)

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

Example $k=-1$

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

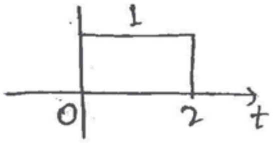
$$x(t) = \begin{cases} 0 \;; & t<0 \\ 1 \;; & 0\le t\le 2 \\ 0 \;; & t>2 \end{cases}$$

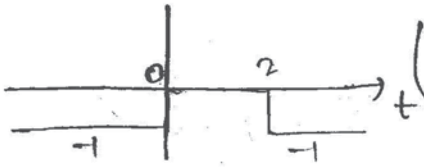
$$y(t) = -1+x(t)$$

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

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

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

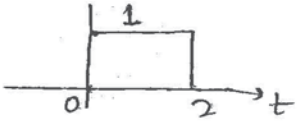




(downward shifting)

(3) Time - Scaling :-

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



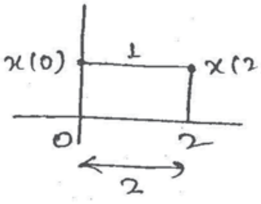
Case (i) when $a > 1$:- (time compression)

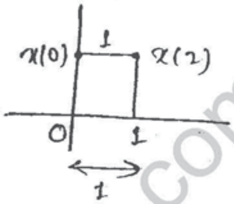
Example $a = 2$

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

$t=0 \rightarrow x(0)$

$t=1 \rightarrow x(2)$



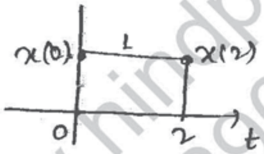


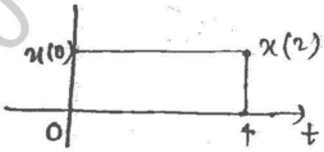
(time compression)

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

example $a = 0.5$

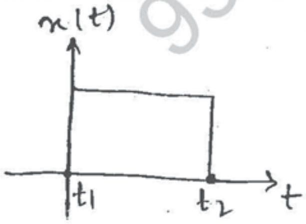
$$x(t) \longrightarrow x(0.5t)$$



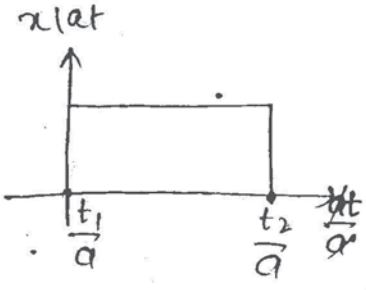


(time expension)

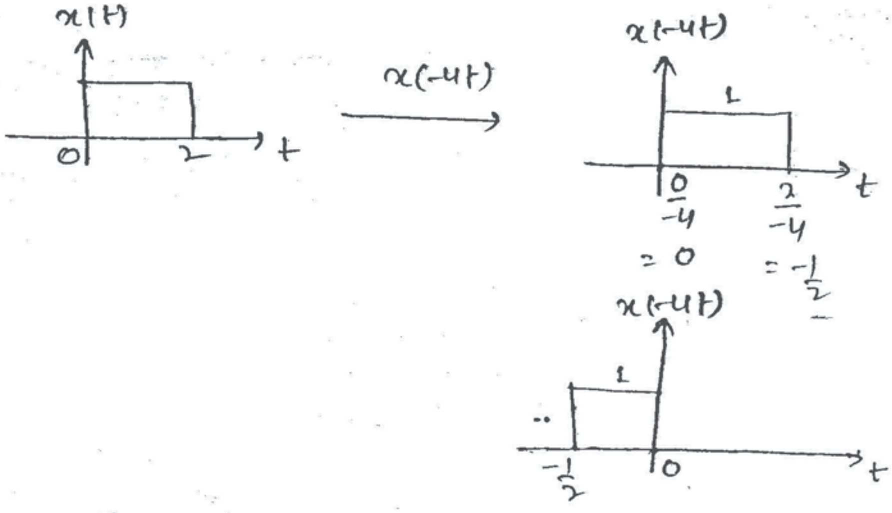
General Rule for time Scaling :-



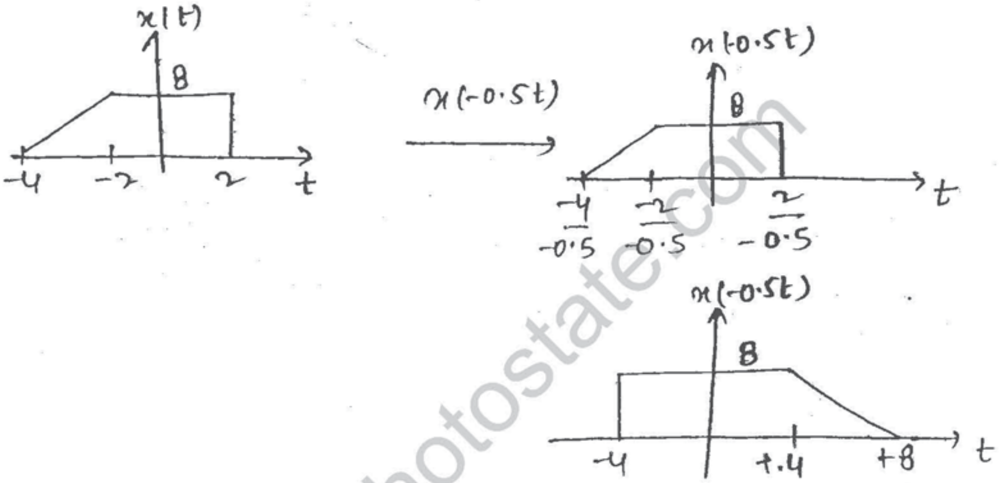
$$\longrightarrow$$



Example :-



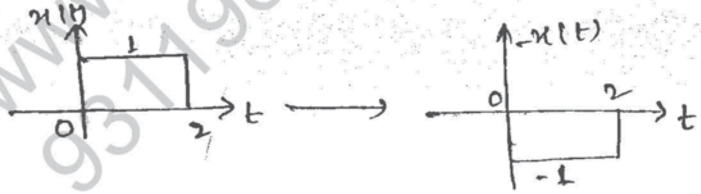
Example :



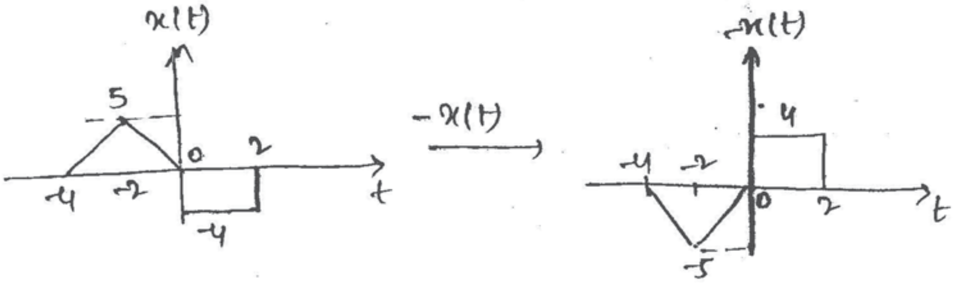
(4) Amplitude Reversal :-

(folding about x axis)

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

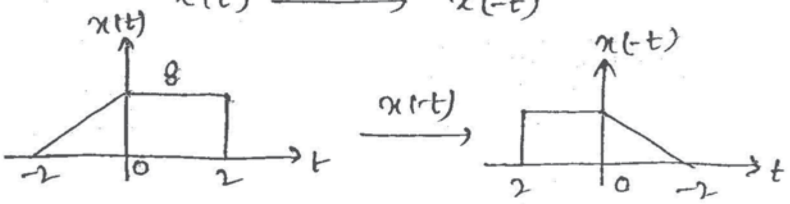


Example :-

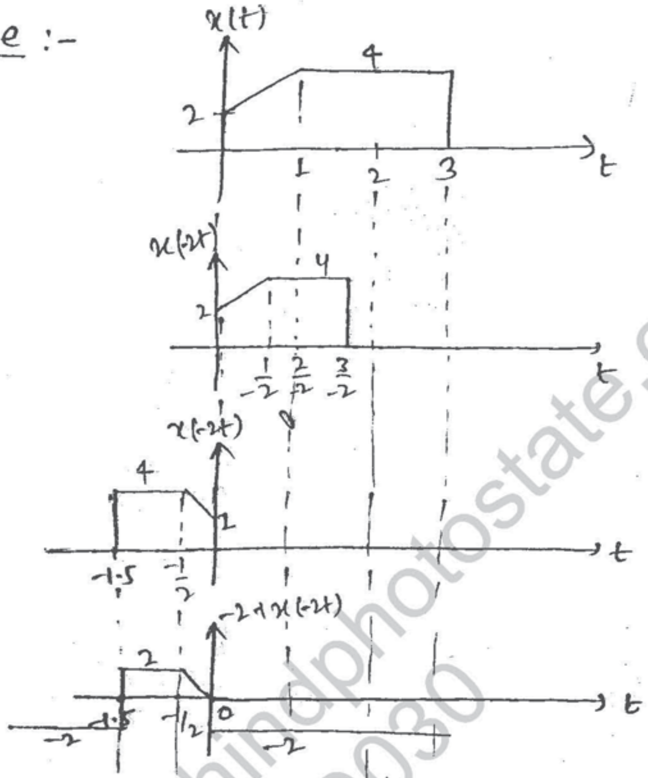


(5) Time - Reversal :- (f ding about y-axis)

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

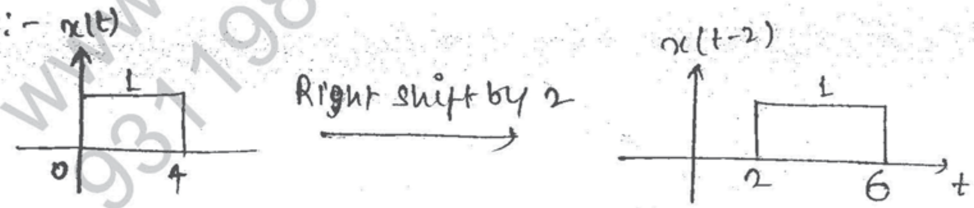


Example :-

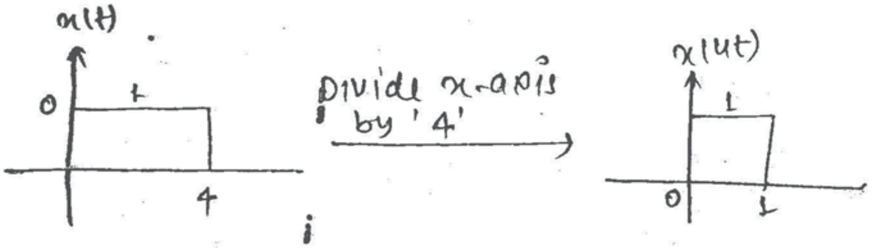


Find y(t) = ?
where y(t) = -2 + x(-2

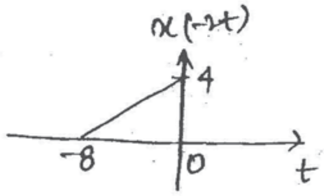
Example :-



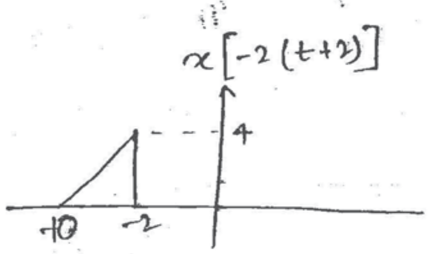
Example:



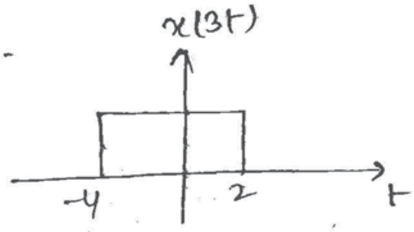
Example :-



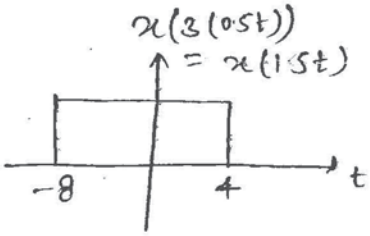
$\xrightarrow[\text{by 2}]{t \to t+2 \text{ Left shift}}$



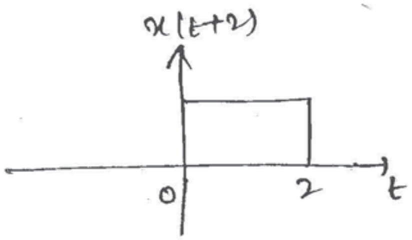
Example :-



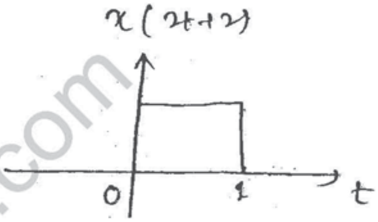
$\xrightarrow[\text{by 0.5}]{t \to 0.5t \text{ divide x-axis}}$



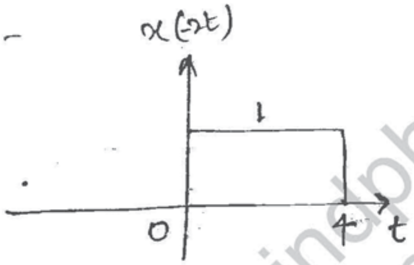
Example :-



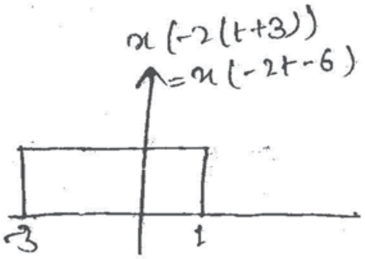
$\xrightarrow[\text{by 2}]{t \to 2t \text{ divide x-axis}}$



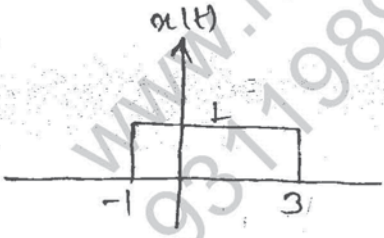
Example :-



$\xrightarrow{t \to t+3 \text{ Left shift by 3}}$



***
Question :



Draw signal y(t)

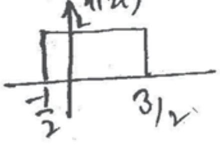
$y(t) = x(2t+3)$

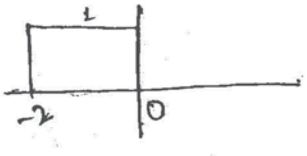
$= x(2(t+1.5)$

Solution :- method (1)

$x(t) \xrightarrow{\text{time scaling}} x(2t) \xrightarrow{L.S = 1.5} x(2t+3)$ or $x(2(t+1.5))$

यहाँ 3 से LS नहीं करेंगे |





MADE EASY

Electrical Engineering

Toppers Handwritten Notes

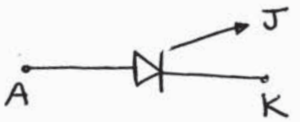
06.ANALOG ELECTRONICS

BY- A.RAJKUMAR SIR

-: 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.

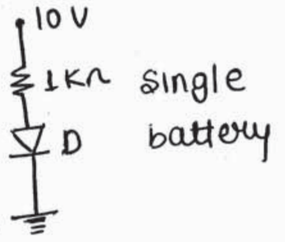
Rule 2 :- Indicate the current direction of each diode from A to K.

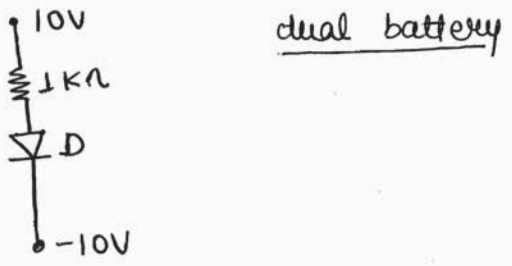
Rule 3 :- Check ~~th~~ calculate I_D of each diode by using KVL or KCL

Status : $I_D > 0$; D = ON

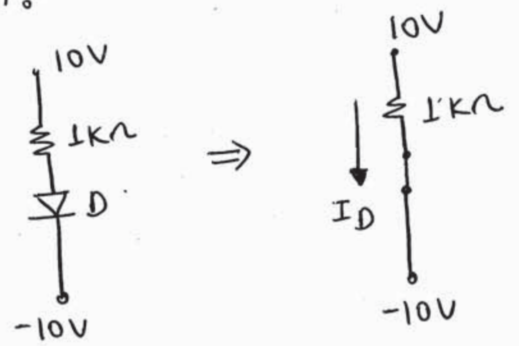
$I_D < 0$; D = OFF

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





Solution :-

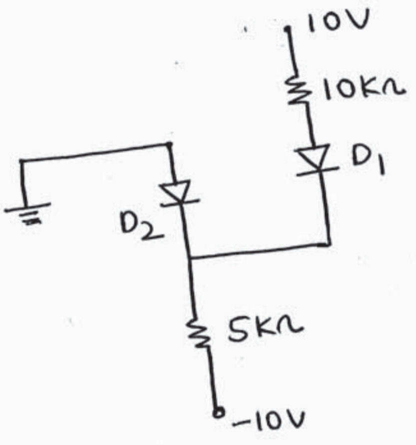


$$I_D = \frac{10-(-10)}{1K}$$

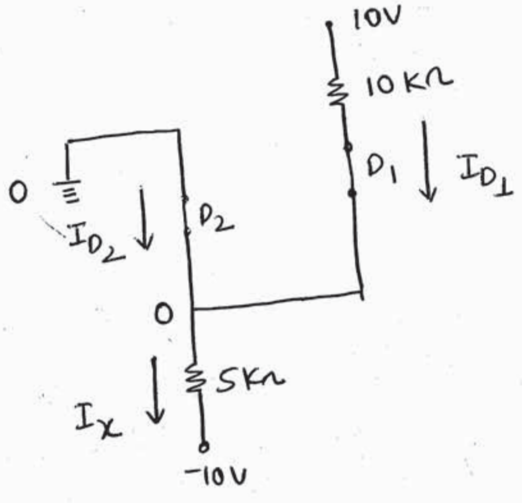
$$= 20mA > 0$$

$\hookrightarrow$ 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'

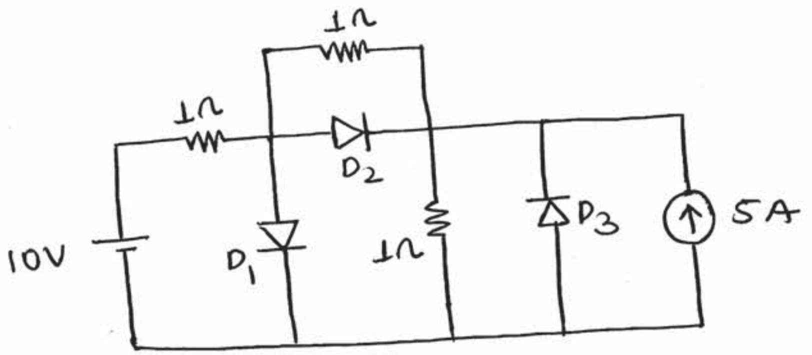
$$I_{D_1} + I_{D_2} = I_x$$

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

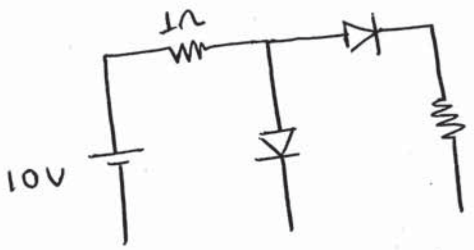
$$I_{D_2} = 1mA > 0$$

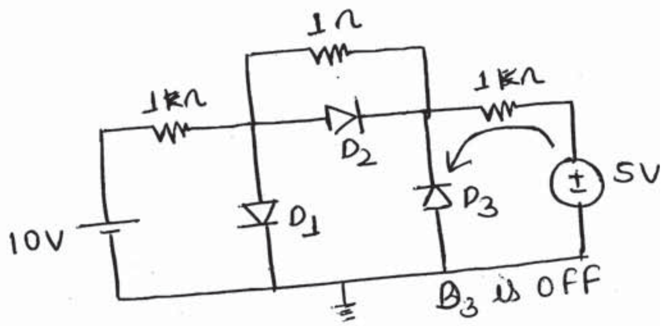
$\hookrightarrow$ D_2 ON

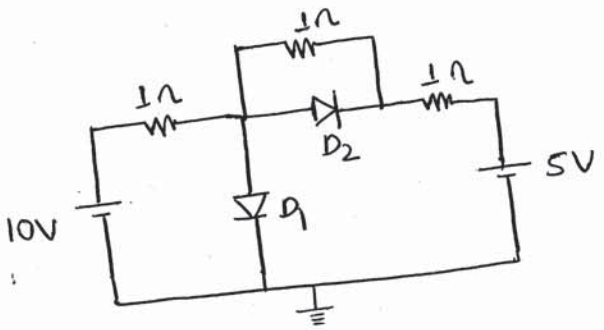
Q.N:- what are the states of the three ideal diodes of the circui

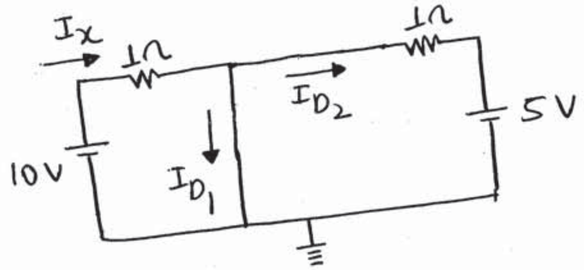


Solution:-









$$I_x = \frac{10-0}{1} = 10A \qquad I_{D_2} = \frac{0-5}{1} = -5A < 0$$

→ D_2 is OFF

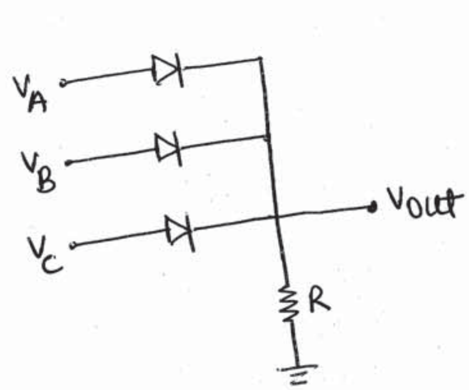
KCL at node a $\quad I_x = I_{D_1} + I_{D_2}$

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

$$I_{D_1} = 15A > 0$$

→ 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

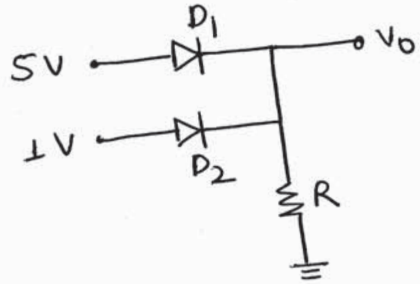
Rule 2 : Indicate V_A & V_K of each diodes

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

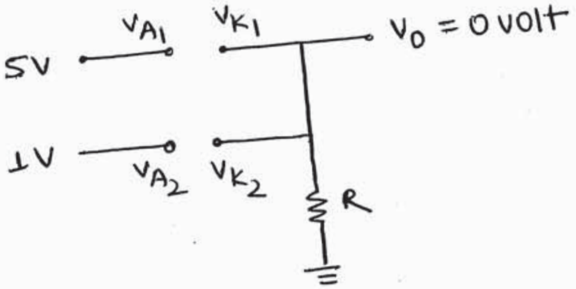
Status : $V_A - V_K > 0$ D = ON

$V_A - V_K < 0$ D = OFF

Example 1 :-



solution :-

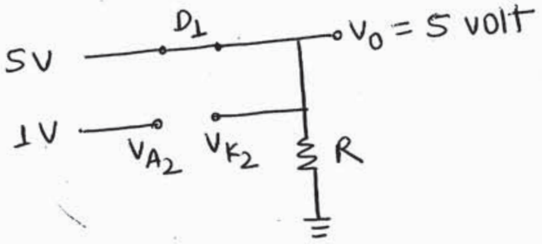


$V_{A_1} - V_{K_1} = 5 - 0$
$= 5 > 0$

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

Two diodes ON simultaneously then recheck condition

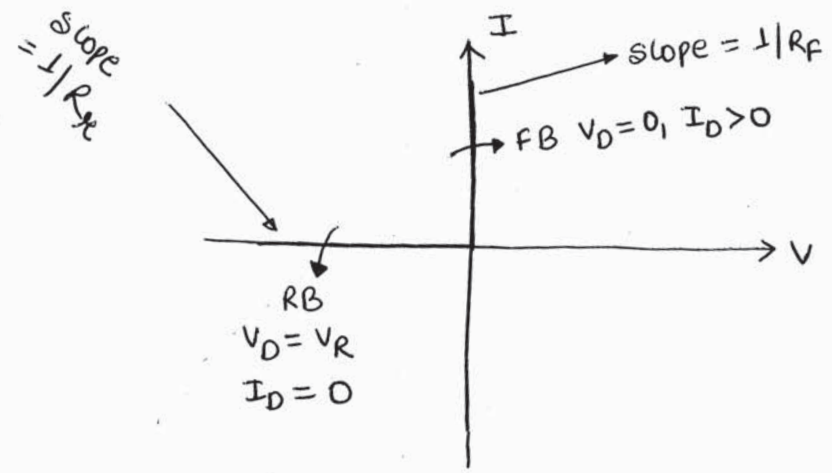
Select D_1 ON first because it is more FB



$V_{A_2} - V_{K_2} = 1 - 5$
$= -4 < 0$
↳ 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 : slope = $\frac{1}{R_F} = \infty \Rightarrow \boxed{R_F = 0}$ ideal diode

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

CVD model :-

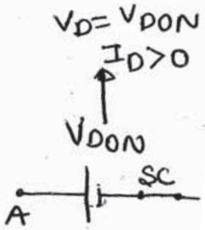
CVD means constant voltage drop model

Practical diode will have cut in voltage V_γ.

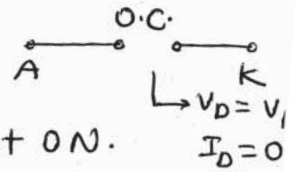
$V_\gamma(si) \longrightarrow 0.5\,V$ to $0.7\,V$

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

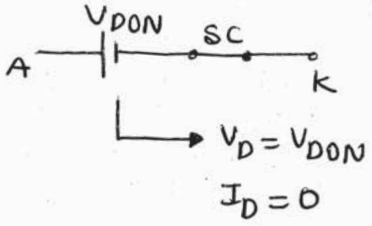
condition for CVD model :- $V_A - V_{K.} > V_{D,ON}$ then D_{ON}



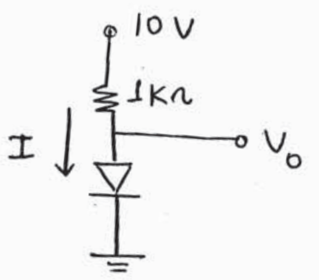
$V_A - V_K < V_{DON}$ then $D = OFF$



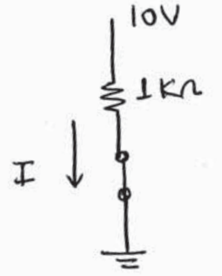
$V_A - V_K = V_{DON}$ then D just ON.



EX1:- Check the status of diode and calculate V_o and I using Idea
& CVD model.



<u>Solution</u>:- Ideal condition:- [SC Test]

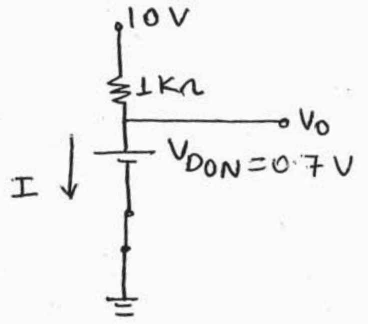


$$I = \frac{10-0}{1K}$$

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

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

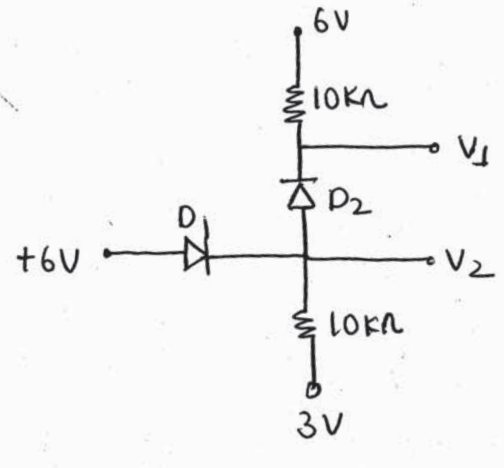
CVD condition:- [SC Test]



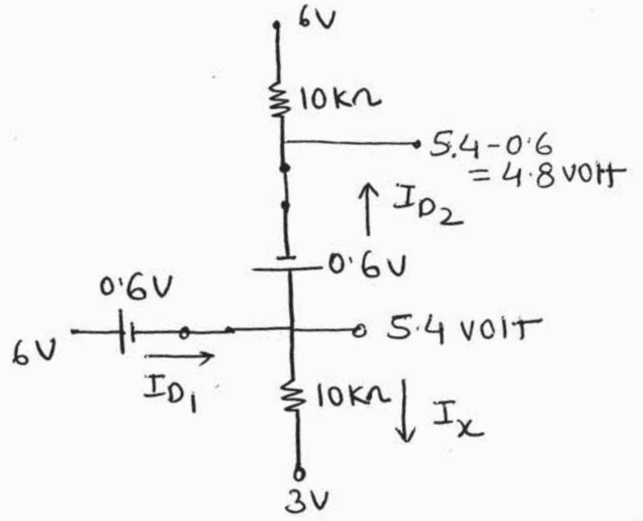
$$I = \frac{10-0.7}{1K} = 9.3mA > 0 \text{ then D ON}$$

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

<u>Q.N:14</u> 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 OF condition

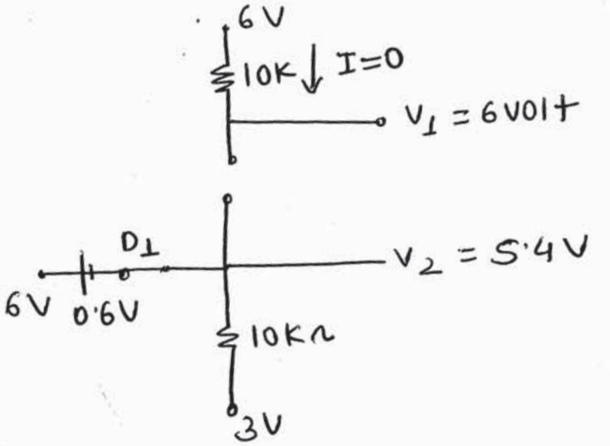
KCL @ 5.4V

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

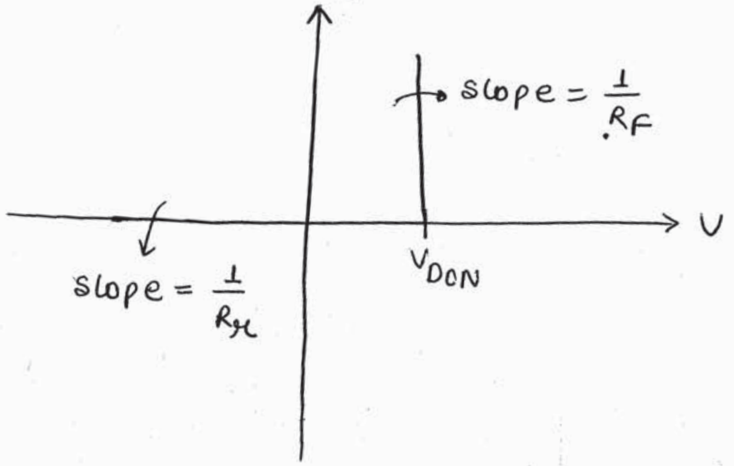
$$= -0.12 + 0.24$$

$$= 0.12\,mA > 0$$

→ D_1 is in ON condition



V-I characteristic of CVD model :-



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07.POWER SYSTEM 1

BY- BALA JI SIR

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, 400V

Houses uses - 230V (phase voltage)

Frequency f = 50Hz

HVDC ± 500KV, ± 800KV, f = 0Hz

QN:- 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
Hydro : 46209.22 MW

Gas : 24924 MW
Diesel : 509.71 MW

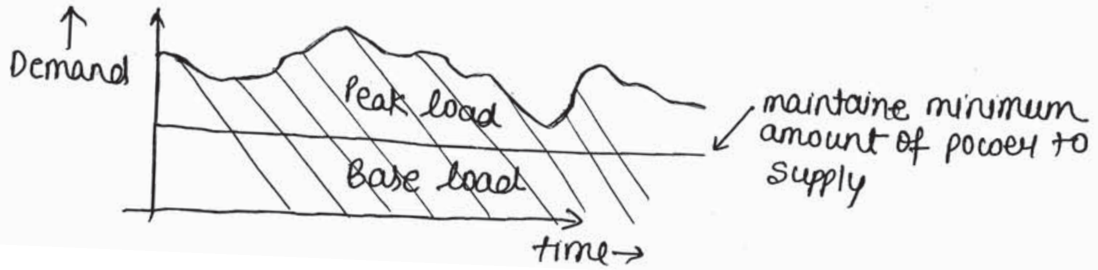
Nuclear : 6780W
Renewable Energy source : 95012.59 MW

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

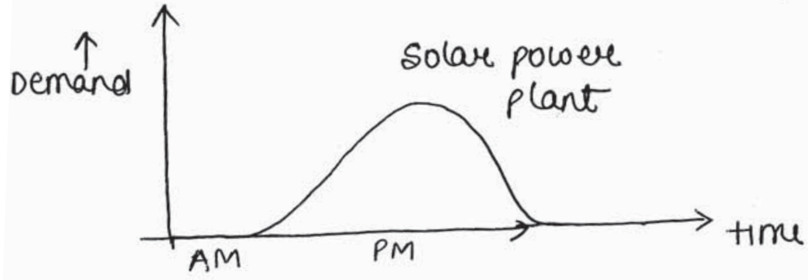


Base load -: Thermal plant   Next to peak load : Gas, wind, solar

Peak load -: Hydro plant

1 Kwhr = 1 unit

2019-20 1208 kwh per capita consumption



Objectives of Power system :-

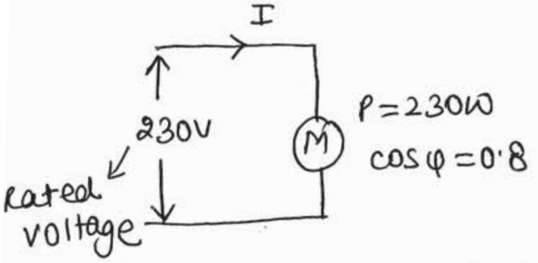
(i) Cost of electric energy must be low.

— 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) Maintaine constant voltage i.e; supply rated voltage to consumer



$$P = V I \cos\varphi$$

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

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

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

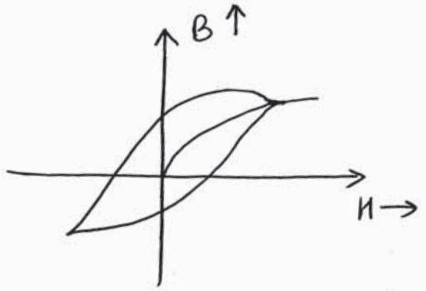
current drawn by motor is high value. this will causes overheating

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 : $V = 4.44 f \phi_m N$

$\downarrow \frac{V}{f} \propto \phi \uparrow$ → 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)

37 → strands, 30 → Al, 7 → steel

5 layer ACSR (61 - 54/7)

61 → strands, 54 → Al, 7 → steel

$$\boxed{\begin{array}{l} \text{No. of strands : } N = (3x^2 - 3x + 1) \\ \text{Total Dia } D = (2x-1)d \end{array}}$$

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.

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

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

$$I = 759.67A$$ carrying current by Moose

Tower configuration :-

3 bundle conductor not practically used due to mechanical strength.

Classification of Transmission line :-

(i) Short line – $l < 80\text{km}, \; lf < 4000$

(ii) Medium line – $80 \le l \le 200 \text{ km}, \; 4000 \le lf \le 10000$

(iii) Long line – $l > 200 \text{ km}, \; lf > 10000$

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

EX-: short line $l \times f = 80 \times 50 = 4000$

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 20km?

Solution:-

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

↳ $4000 \le lf \le 1000$ → Medium

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

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

Transmission line Parameters :-

(i) Inductance (L)
(ii) capacitance (C)
(iii) Resistance (R)
(iv) conductance (G)

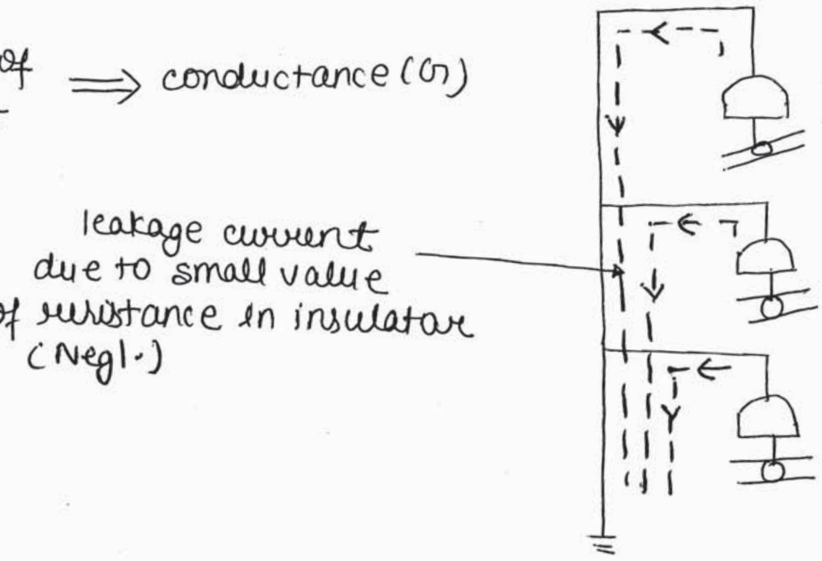
Inductance :-
current → produce flux → link with other 2 phase also i.e;
due to flux (self + Mutual) produces inductance in it.

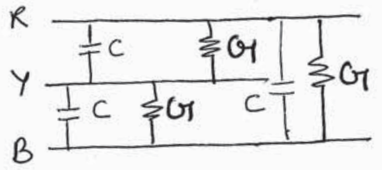
Capacitance :-
Two metal is separated by some distance & operating at some voltage produce capacitance in it & ground capacitance also exists.

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.

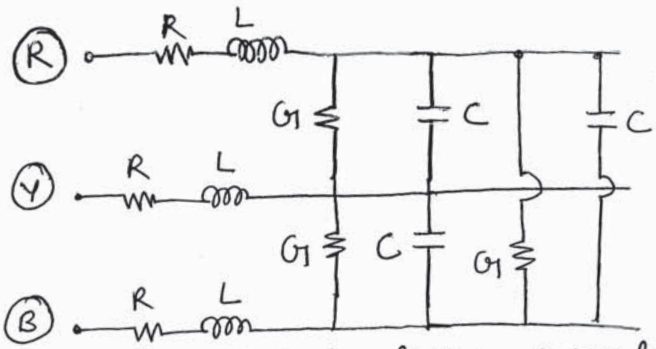
Electrical equivalent of leakage current ⟹ conductance (G)





series element ⇒ R & L

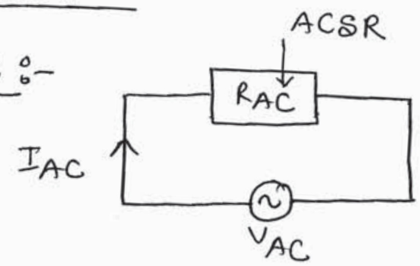
shunt element ⇒ C & G



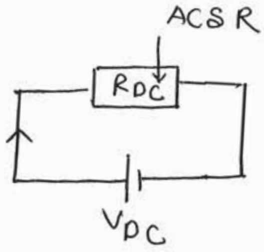
-: Electrical eqt of x-mission line :-

esistance :-

HVAC :-

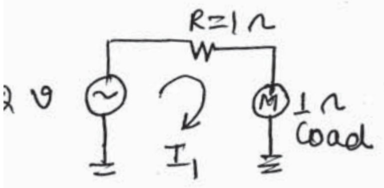


HVDC :-

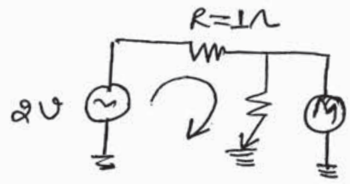


$\boxed{R_{AC} > R_{DC}}$ Due to (i) skin effect
(ii) proximity effect

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



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



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

$\boxed{I_2 = 2I_1}$ during short ckt condition

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

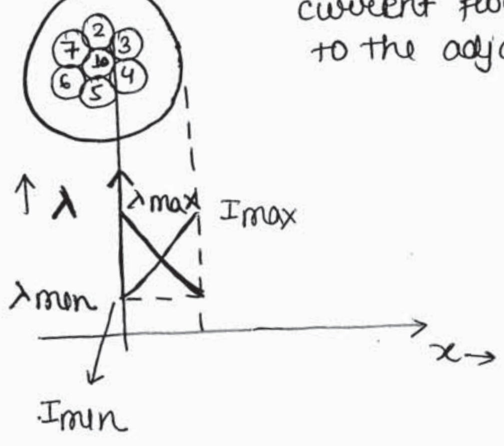
RTS : KN

(i) Skin effect :-

ⓐ 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



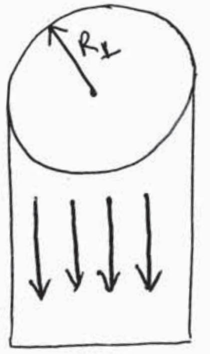
λ_{max} i.e; L_{max} then $X_L \uparrow$

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

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

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

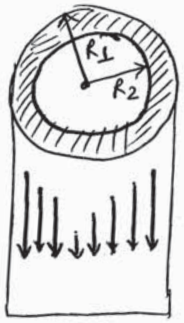
HVDC :



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

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

HVAC :



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

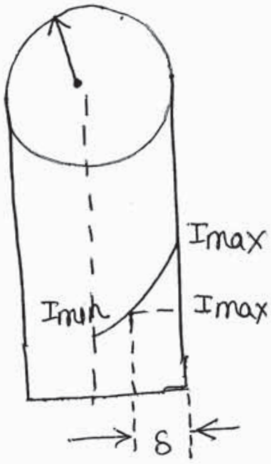
ⓑ Due to skin effect, effective area of current flowing path is reduced which causes $R_{AC} > R_{DC}$. in HVAC system.

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

ⓓ 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) :-



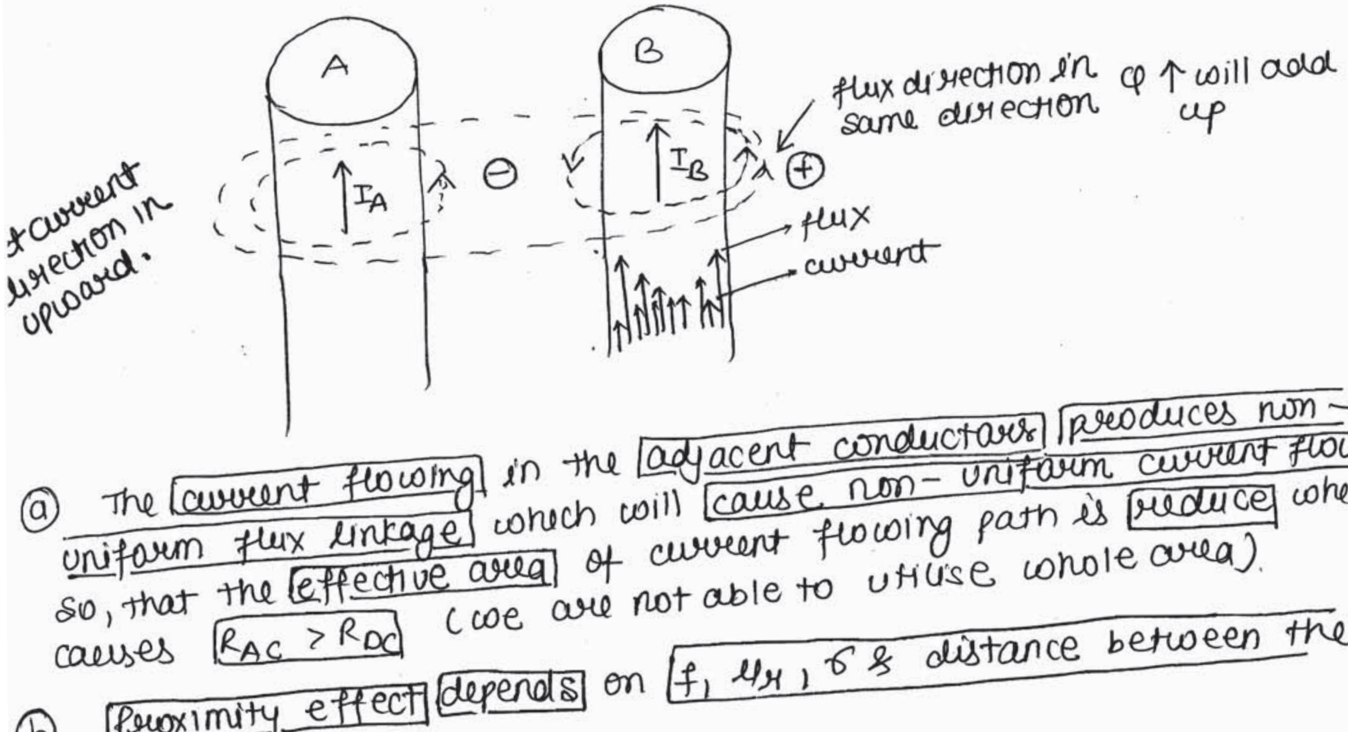
ⓐ The depth of the conductor at which the current is drop to (1/e) time of the maximum current & that depth is called as skin depth.

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

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

ⓒ In HVDC, no skin effect because f = 0

Proximity effect :-



current direction in upward.

ⓐ 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).

ⓑ Proximity effect depends on f, μ_r, σ & distance between the conductor

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

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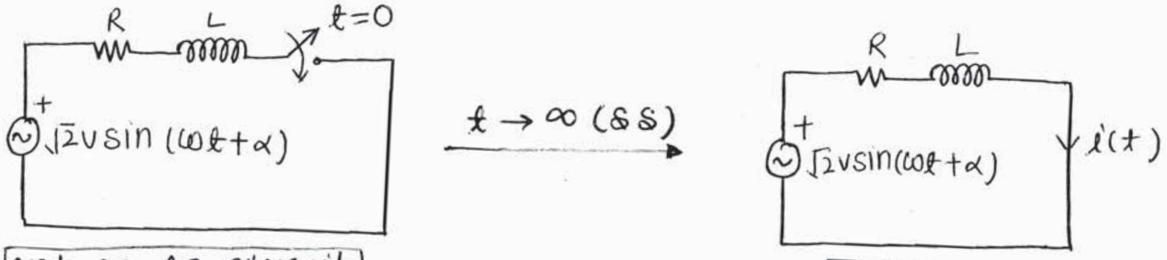
08.POWER SYSTEM- II

BY- BHOOPENDR SIR

-: Power-System - II :-

Power Analysis of AC circuit :-

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



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

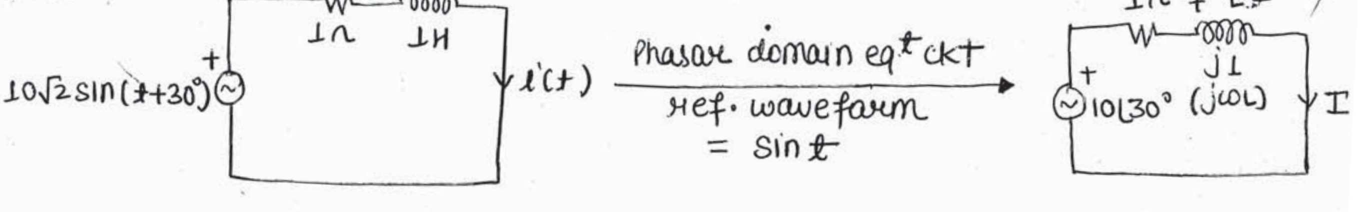
$i(t) = \sqrt{2}I\sin(\omega t+\beta)$

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 circu is computed using phasor technique.

Ex-:



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.

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

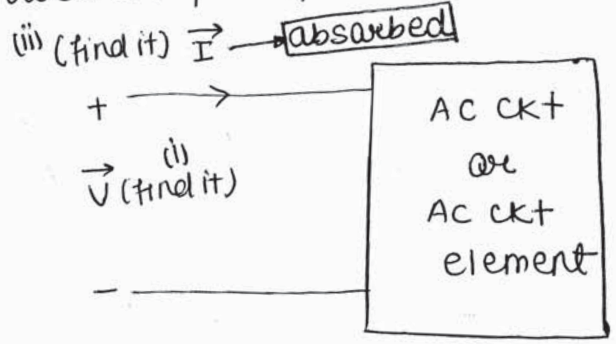
	Time domain	Phasor domain	Frequency domain
Inductor	Henery (H)	jX or jωL	sL
Capacitor	Farad. (F)	1/(jωC)	1/sC
Resistance	R	R	R

$$I(t) = \frac{10\angle 30^\circ}{1+j1} = \underset{\boxed{\text{RMS value}}}{\underset{\downarrow}{\frac{10}{\sqrt{2}}}}\angle{-15^\circ} = \underset{\boxed{\text{Maximum value}}}{\underset{\downarrow}{10\sin(t-15^\circ)}}$$

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

$$S = \vec{V}\,\vec{I}^{\,*} \quad \overset{(ii)}{[\text{find it}]}$$
$$= P + jQ$$

(iv) Then;

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

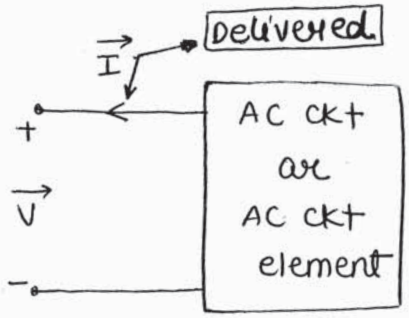
Q = Reactive power / lagging VAR absorbed by the AC ckt element or AC ckt. (VAR)

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

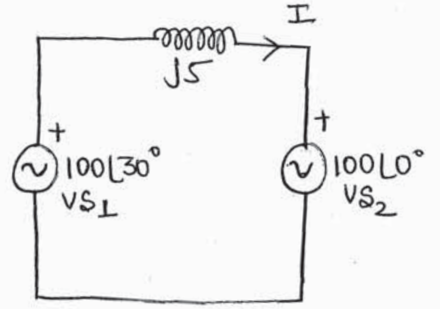
Q = Reactive power/ lagging VAr delivered by the AC ckt element or AC ckt.

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

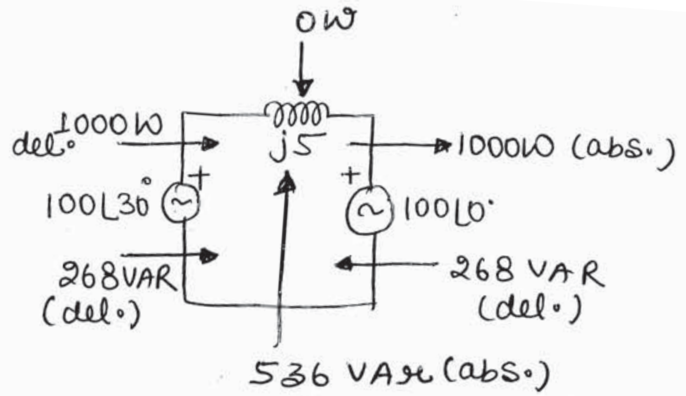
$$S = (100\angle 0^\circ)(10.35\angle 15^\circ)^* = 1000 - j268$$

VS_2 : absorbs 1000W and delivers 268 VAr

complex power delivered by VS-1

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

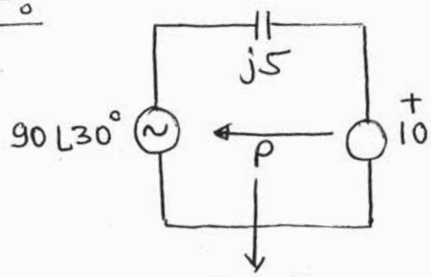
VS_1 : delivered 1000W and delivers 268 VAr

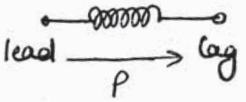


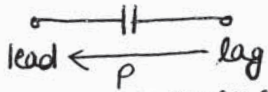
$= 268\,VAr + 268\,VAr$ & [Active power = 0 (always)]

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-:



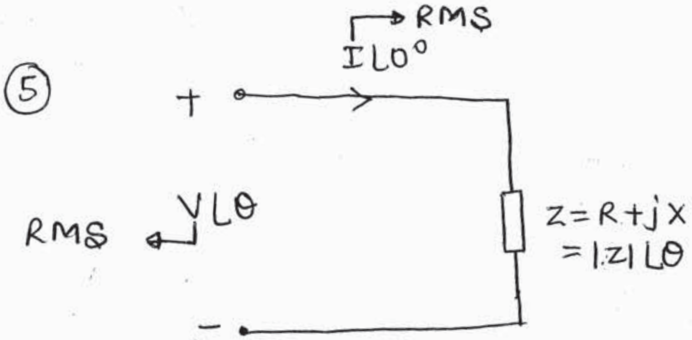




But in power system in series capacitor is not present i.e; not power systm ckt.

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

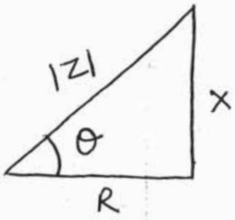
$Y = \frac{1}{Z} = G + jB$

B = −ve → inductance

B = +ve → capacitance

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

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



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

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

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

$= I\angle 0^\circ\, Z\angle\theta$

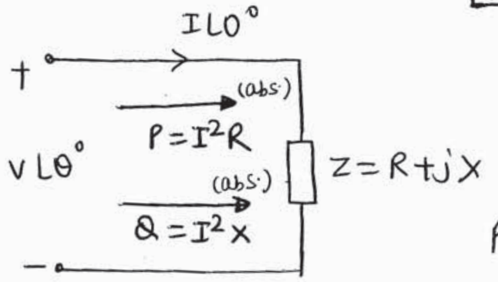
$= IZ\angle\theta = V\angle\theta$

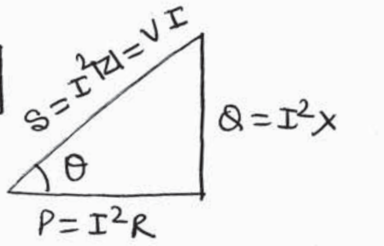
so, complex power absorbs by $Z = R + jX$

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

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

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





:- power triangle :-

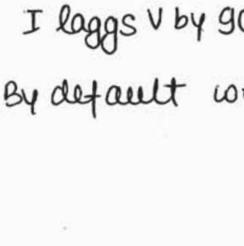
$$p.f. = \cos\theta = \frac{P}{S}$$

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

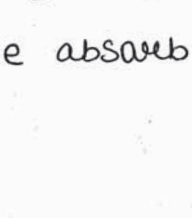
$\boxed{X > 0 \text{ (inductive)}} \longrightarrow$ $Q > 0$ i.e; inductive Impedance absorbs Reactive power / lagging VAr (or) inductive Impedance delivers leading VAr

$\boxed{X = 0 \text{ (Resistive)} \longrightarrow Q = 0}$

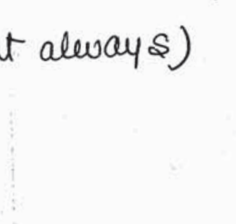
$\boxed{X < 0 \text{ (capacitive)}} \longrightarrow$ $Q < 0$ i.e; capacitive impedance delivers Reactive power / lagging VAr (or) capacitive Impedance absorbs leading VAr



I laggs V by 90°



I leads V by 90°

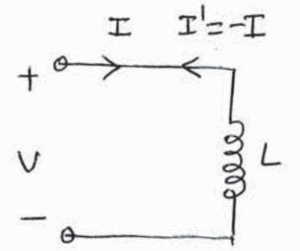


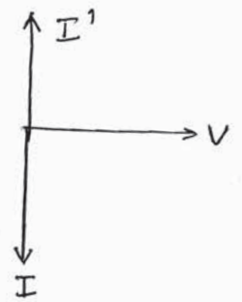
I leads V by 90°

I lags V by 90°

(By default we take absorb current always)

Ex-:





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

requirement of flux get excess in m/c then it will deliver reactive power

(ii) underexcited synchronous M/C → absorbs reactive power / lagging VAR i.e; lagging current (or) delivers leading VAr i.e; leading current

[Always]

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

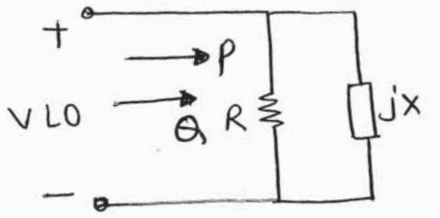
Overexcited syn. motor → motor absorbs the current i.e; absorbs leading VAR

we can say that $Pf \equiv$ leading

Over excited Sync. Generator $\longrightarrow$ Generator delivers the current i.e; delivered lagging VAr i.e lagging current

we can say that p.f ≡ lagging

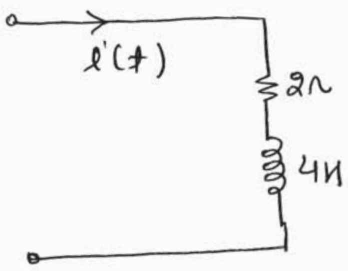
#



$$\boxed{P = \frac{V^2}{R}} \rightarrow \text{RMS value}$$

$$\boxed{Q = \frac{V^2}{X}} \rightarrow \text{RMS value}$$

Ex-:



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

$P = ?$ $Q = ?$

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

$[X = \omega L]$
$\omega = 2, L = 4$

$$Q = I^2X = \left(\frac{10}{\sqrt{2}}\right)^2 \times (2\times4) = 400\,\text{VAr}$$

I = RMS value

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

A polyphase system is said to be balance if

(i) The $\boxed{\text{magnitude}}$ of $\boxed{\text{corresponding quantity}}$ are $\boxed{\text{equal in each phase.}}$

(ii) The $\boxed{\text{phase difference}}$ b/w the corresponding quantities is given by

$$\boxed{\theta = \frac{360^\circ}{n} \;;\; n \neq 2}$$
$$\boxed{\theta = 90^\circ \;;\; n = 2}$$

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

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

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

MADE EASY

Electrical Engineering

Toppers Handwritten Notes

Electrical Machine

By-Murli Sir

MADE EASY

Electrical Engineering

Toppers Handwritten Notes

INDUCTION MACHINE

By-Murli Sir

-: Induction machine :-

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

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

(i) Induction Generator
(ii) Induction motor

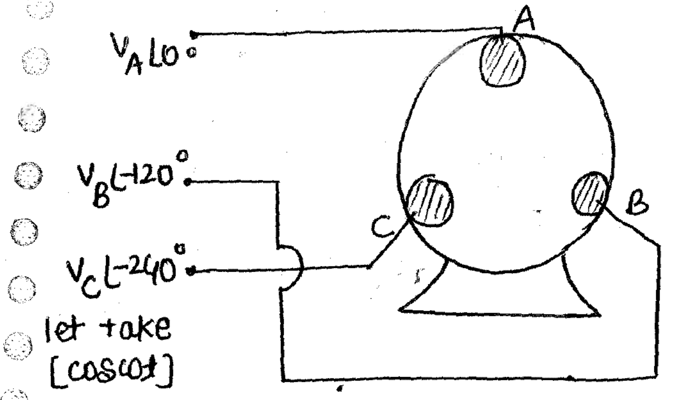
Rotating Magnetic field (RMF) :-

In I/M, the $\boxed{\text{flux}}$ is $\boxed{\text{not stationary}}$, it is $\boxed{\text{rotating}}$

The $\boxed{\text{basic requirement}}$ to $\boxed{\text{produce}}$ the $\boxed{\text{rotating magnetic field}}$ is

(i) $\boxed{3\varphi \text{ supply}}$ ($\boxed{120° E}$ phase displacement $\boxed{\text{w.r.t. time}}$) } Balance
(ii) $\boxed{3\varphi \text{ winding}}$ ($\boxed{120° E}$ phase displacement $\boxed{\text{w.r.t. space}}$) }

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

$$mmf = NI$$

$$V_A\angle 0° \longrightarrow I_A N_A \longrightarrow \vec{F_A} \longrightarrow \vec{\varphi_A}$$
$$V_B\angle -120° \longrightarrow I_B N_B \longrightarrow \vec{F_B} \longrightarrow \vec{\varphi_B}$$
$$V_C\angle -240° \longrightarrow I_C N_C \longrightarrow \vec{F_C} \longrightarrow \vec{\varphi_C}$$

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.)

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

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

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

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

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

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

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

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

$[* + * + * = 0]$

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

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

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.

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

$\boxed{N = rpm}$ $\boxed{N/60 = rps}$ $\boxed{\omega = 2\pi f \text{ elet-rad/sec}}$

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

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

similar, $\omega_e = \frac{P}{2}\theta_m \Rightarrow \cancel{2\pi} f = \frac{P}{\cancel{2}} \cdot \frac{\cancel{2\pi} N}{60}$

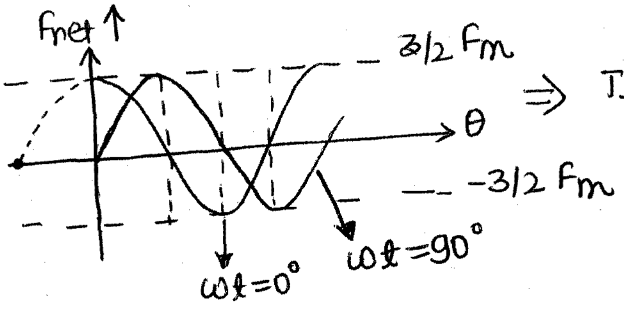
$$\boxed{f = \frac{PN}{120}}$$

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

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 $F_{net} = \frac{3}{2} F_m \sin\theta$



⇒ Travelling or moving with constant ampli. 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.

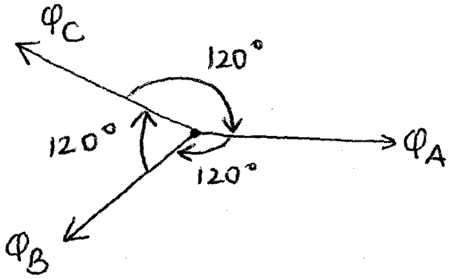
NOTE:- By reversing the phase sequence the direction of movement of mmf is also reverse.

Another approach:-

$\varphi_A = \varphi_m \sin\omega t$

$\varphi_B = \varphi_m \sin(\omega t - 120^\circ)$

$\varphi_C = \varphi_m \sin(\omega t - 240^\circ)$

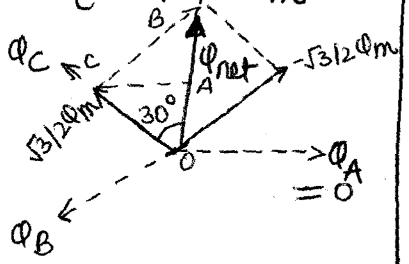


At $\omega t = 0^\circ$

$\varphi_A = 0$

$\varphi_B = -\sqrt{3}/2\,\varphi_m$

$\varphi_C = \sqrt{3}/2\,\varphi_m$



$OB = 2OA$, $\angle AOC = 30^\circ$

from $\triangle OAC$

$\cos 30^\circ = \frac{OA}{OC}$

$OA = OC\cos 30^\circ$

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

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

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

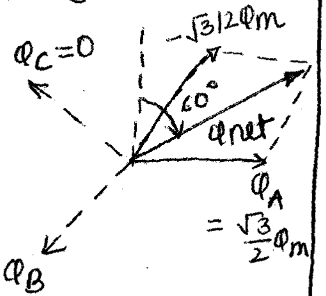
$\boxed{\varphi_{net} = \frac{3}{2}\varphi_m}$

At $\omega t = 60^\circ$

$\varphi_A = \sqrt{3}/2\,\varphi_m$

$\varphi_B = -\sqrt{3}/2\,\varphi_m$

$\varphi_C = 0$



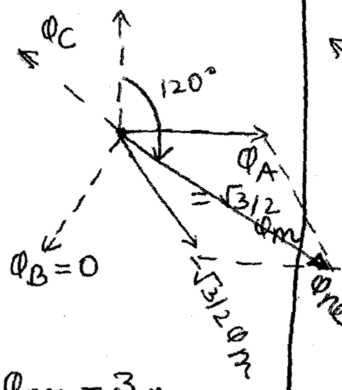
$\varphi_{net} = \frac{3}{2}\varphi_m$

At $\omega t = 120^\circ$

$\varphi_A = \sqrt{3}/2\,\varphi_m$

$\varphi_B = 0$

$\varphi_C = -\sqrt{3}/2\,\varphi_m$



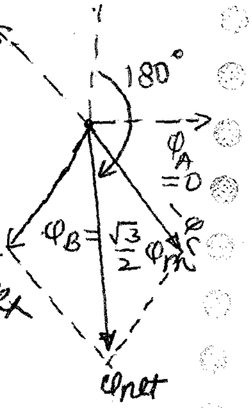
$\varphi_{net} = \frac{3}{2}\varphi_m$

At $\omega t = 180^\circ$

$\varphi_A = 0$

$\varphi_B = \sqrt{3}/2\,\varphi_m$

$\varphi_C = -\sqrt{3}/2\,\varphi_m$



$\varphi_{net} = \frac{3}{2}\varphi_m$

Synchronous
$\Downarrow$
i.e, time (moving together with time)

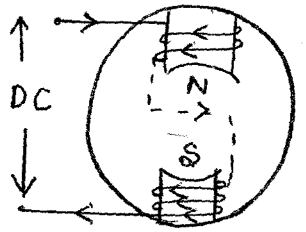
when flux rotate in the m/c then that flux speed will be synchronous speed. It depends on two factor which are frequency and number of pole.

$\varphi_{net} = \frac{3}{2}\varphi_m$ $\boxed{N_S = \frac{120f}{P}}$

Characteristics of RMF :-

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

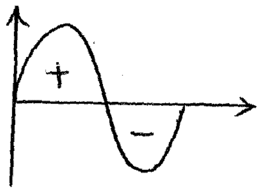
(ii) RMF revolves with $\boxed{N_S = 120f/P}$



[To know North pole or south pole we have to apply right hand gri 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.

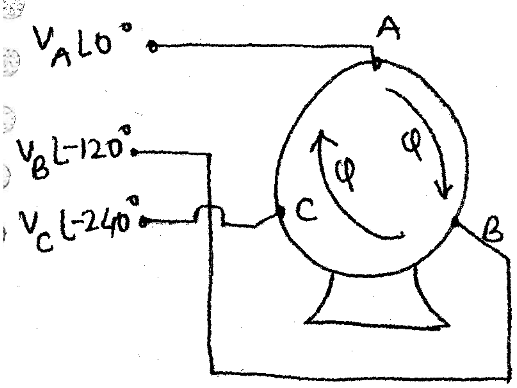
when we talking about AC supply with $f = 1Hz$ i.e, 1 cycle in 1se

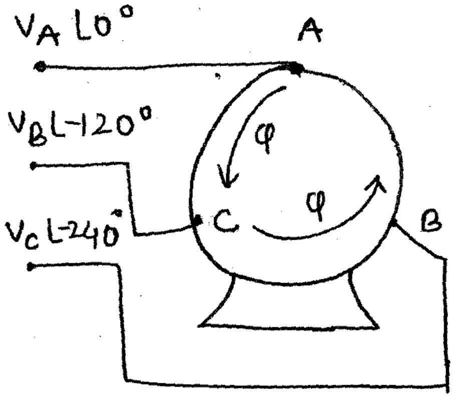


So in +ve cycle the polarity of pole is same as before but in −ve cycle N → S & S → N. (or) North at top → bottom
South at bottom → top

$$\boxed{N_S \propto \frac{1}{P}}$$

(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

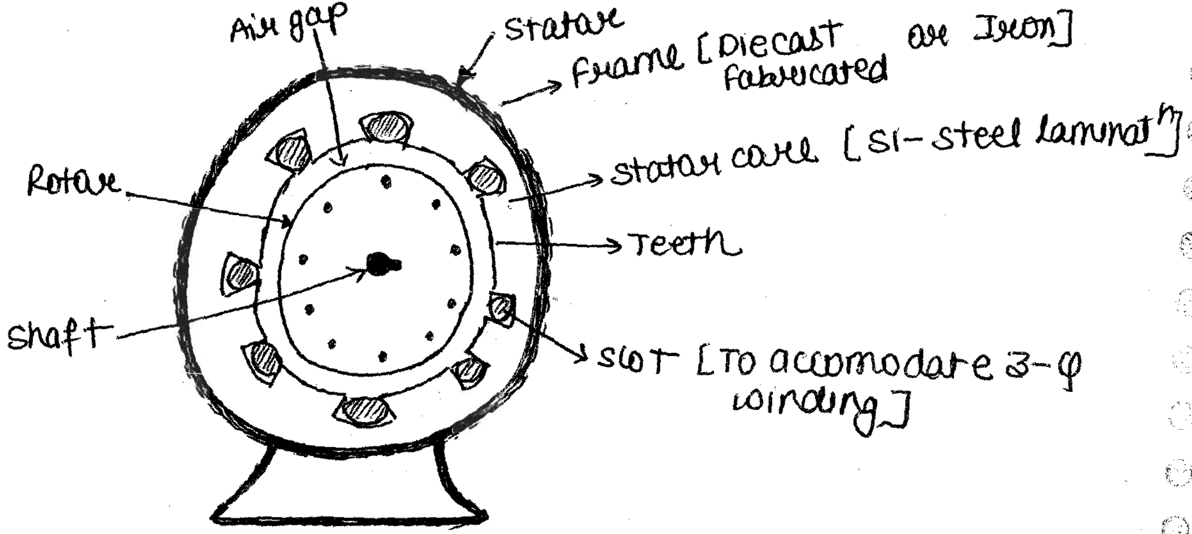
$$\text{Flux} = \frac{\text{mmf}}{\text{Reluctance}}$$

(0.3mm to 4mm)

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

Core :- Core is laminated structure [Si-steel lami^n 0.35-0.5 mm thickness]

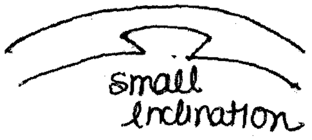
Slot :- slot offer mechanical protection to the winding.



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 mehanical 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 CRGO 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 maintaine Reluctance to be minimum as much as possible the for this we have to maintaine least possible air gap. (0.3mm to 4mm)

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

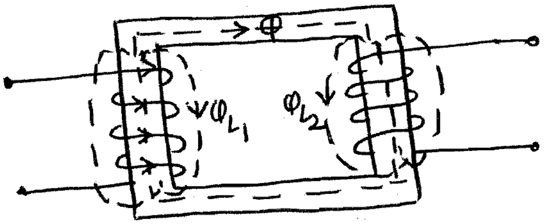
Air gap ↑ → I_m ↑
↳ Drawback

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 :-

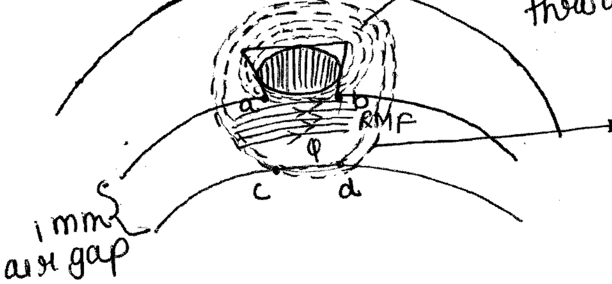
- ⓐ Easy to place the winding in slot, it is so easy.
- ⓑ During maintenance, repaire or routine service
- ⓒ Simple design
- ⓓ leakage flux :



⇒ If flux is linking with two winding then it is usful 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



nothing is ideal so due to which some part of flux is leaking through the slot

Not leakage flux because it linking stator & rotor both. [useful flux]

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. So, air the air gap between a and b is within the stator. 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 least possible.

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

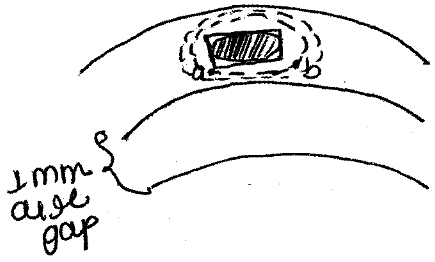
Reluctance ↑ → flux ↓ [leakage] then leakage reactan ↓

&angle 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 through the stator. & leakage

so, leakage flux will be higher. Due to reactance will be higher. this lagging p.f. (angle) will be low.

then p.f ↑.



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Electrical Engineering

Toppers Handwritten Notes

Synchronous Machine

By-Murli Sir

SYNCHRONOUS MACHINES

Gen M-E   Motor E-M   Condenser ↑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 ac voltage which is steped up to much higher value and transmitted through X-mes.
- 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 Faraday 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 so 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 500MVA
11KV

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

* Exci Voltage is DC
125 - 500V DC
1MW power $I = \frac{1000000}{500} = 2000\ A$

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 high current carrying capacity.
(Neutral)

2) **Insulation is effective if armature is on stationary part:** Stationary stote 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.

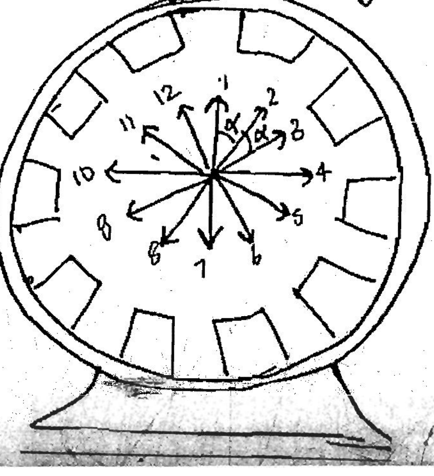
6) Leakage Reactance:- will be less because stator offers more width in the slots and contains more cu per slot. If it is on rotor depth will be high due to less space which produces more leakage reactance

CONSTRUCTION DETAILS:-

- Like all other rotating electric machines it contain stationary 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 Lam 0.5mm thickness) to produce a 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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Electrical Engineering

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Transformer

By-Murli Sir

-: 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 :

Transfers 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.

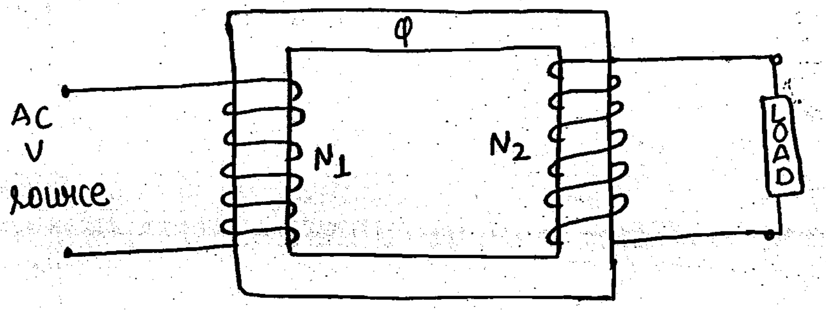
Key word :- Mutual induction principle b/w two or more magnetically coupled circuits (coil/winding)

(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, everything 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 power

(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 :

ⓐ core type transformer
ⓑ shell type transformer

3. Based on No. of phases :

ⓐ $1-\phi$ T/F
ⓑ $3-\phi$ T/F

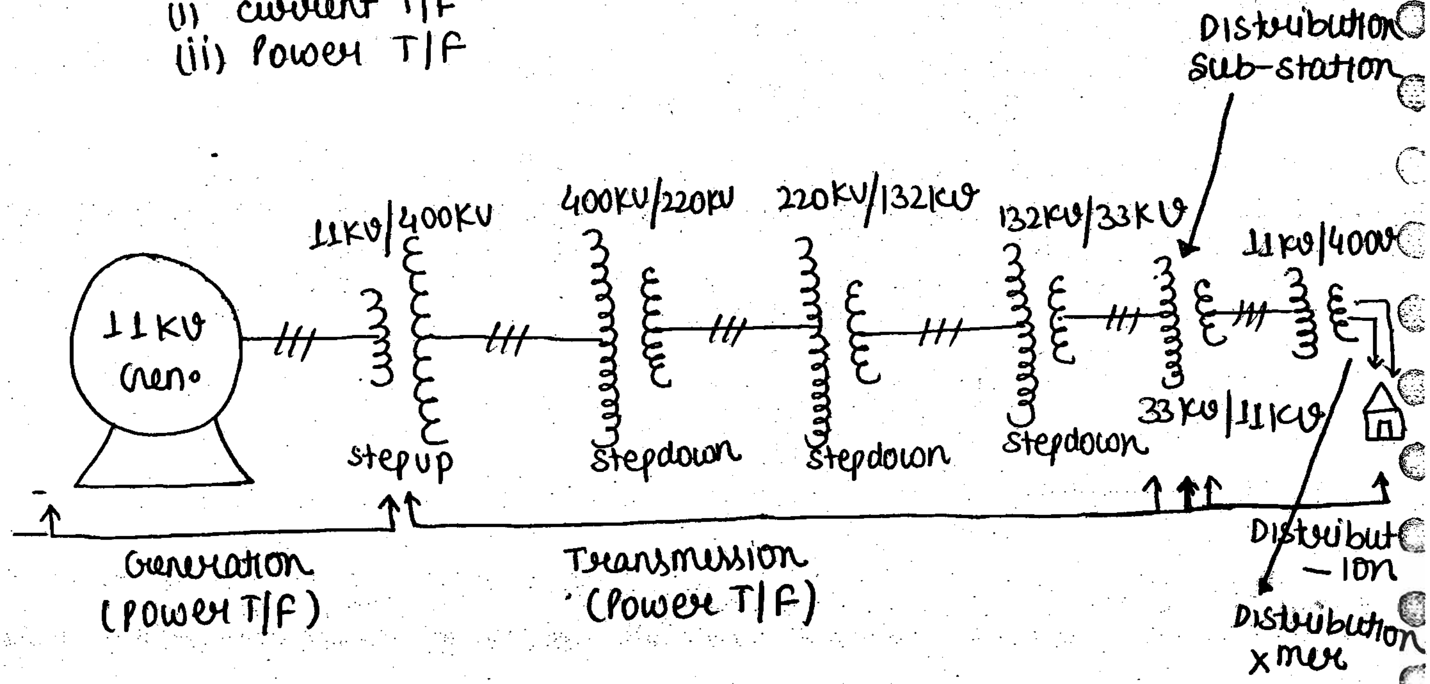
Three $1-\phi$ T/F are internally connected to $3-\phi$ T/F bank.

4. Based on the operating frequency

ⓐ Power frequency T/F (25-400 Hz)
ⓑ Audio frequency T/F (20Hz to 20KHz)

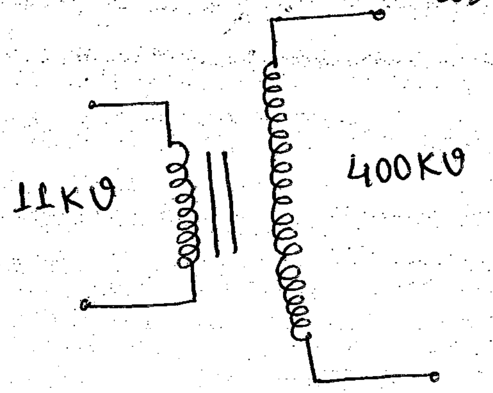
5. Based on Application : Many Numerous kind of T/F

* ⓐ Power system..
  - (i) Power T/F
  - (ii) Distribution T/F
* ⓑ Power electronic
  - (i) Pulse T/F
  - (ii) Gate pulse triggering
* ⓒ Instrumentation
  - (i) current T/F
  - (ii) Power T/F
* ⓓ Electronic & control system



NOTE-:

Step up $\xrightarrow{\hspace{2cm}}$ Step down T/F
$\xleftarrow[\text{can be used as}]{\hspace{2cm}}$



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

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

MADE EASY

Electrical Engineering

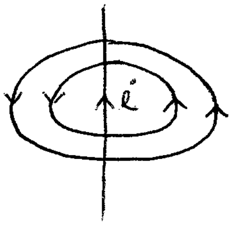
Toppers Handwritten Notes

D.C MACHINE

By-Murali Sir

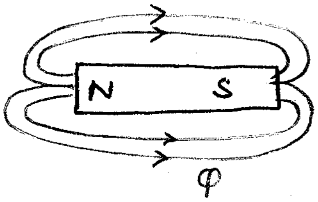
CHRISTIAN OERSTED 1820 Electro magnetism :-

Relation b/w Electricity and magnetism
There is magnetic field around a current carrying conductor



current carrying conductor producing concentric flux line [Right har Thumb rule] By using R-H tump 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.

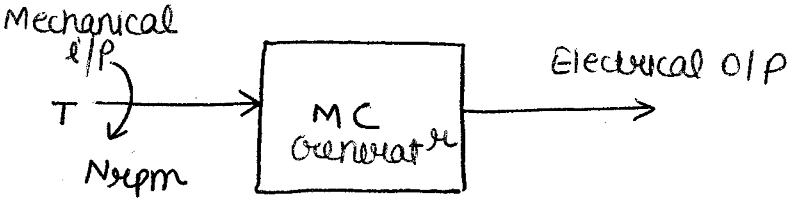
ISSAC NEWTON 1687 Law's of motion

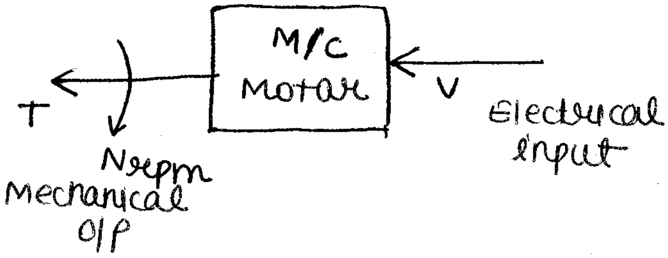
3rd law : Action ⟶ opposite reaction Len'z law -
The result always the opposes the cause of it.

-: DC machine :-

Electrical Machine :-

Electro-Mechanical Energy conversion device

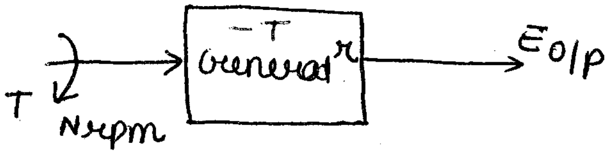




Electreo mechanical : Reverrible process [Pump storage Plant]

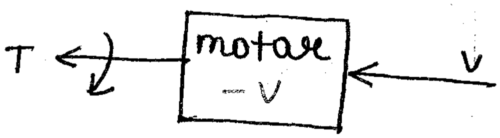
To maintaine the load factor, under light load condition acting like motar as well as making the water go back fare ready the dam far peak load condition acting as generatar.

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



'-' sign denotes the opposite direction

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



M/C → G : V & T generated
M/C → M : T & V generated

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 & T) 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 transformer electro-magnetic conversion takes place. internally.

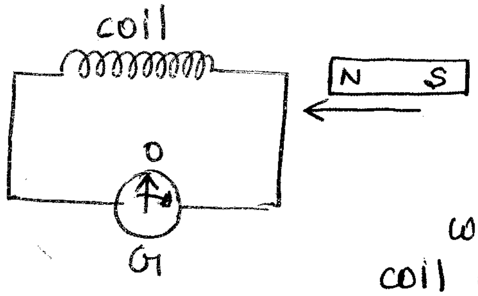
DC Generator :-

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 order to convert mechanical energy into DC electrical energy.

Faraday's law of Electromagnetic 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

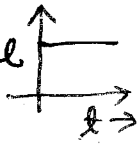
↓ magnet ↓ cu wire

Induced emf

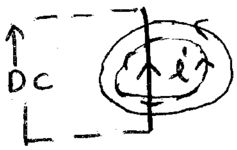
- Dynamically (AC in nature) (involved with motion or speed) flux cutting voltage
- Statically (AC in nature) (NO motion) i.e; stationary

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.

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

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

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

↓ i.-'sign represent lenz's law

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

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)

<u>Three mode of flux linking</u>:-

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

conductor: Rotating

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

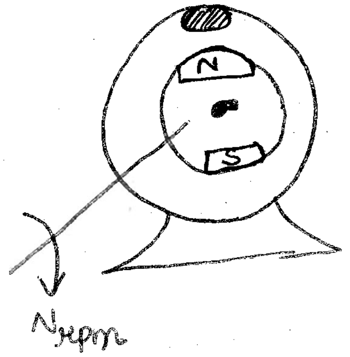
Place a conductor on rotating part & don't rotate the rotating part then there is flux and conductor but missing the rate of change of flux linkage

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.

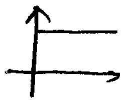
Rate of change of flux linkage occurs in conductor which produces dynamically induced emf.

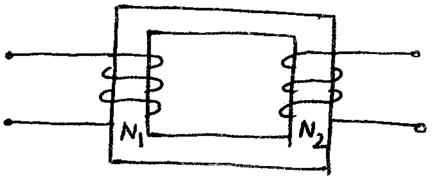
Ex:- Synchronous machines

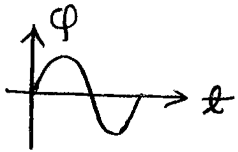
To collect the current from stationary part is so easy.

③ 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)

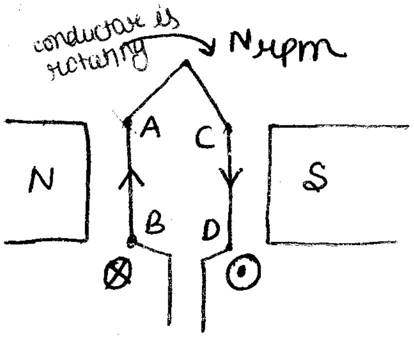
↳ No motion require

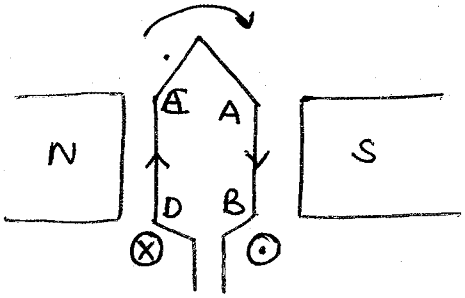
<u>working of a simple loop generator :-</u>

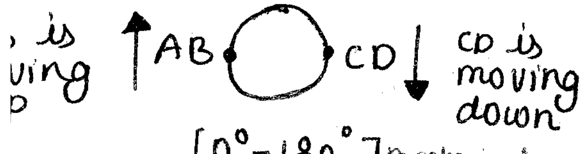
In order to produce induced emf in a conductor, require

ⓐ Flux ⓑ conductor ⓒ prime mover According to FLEMI

Rotate the conductor b/w magnetic field.







[0°-180°] mechanical degree

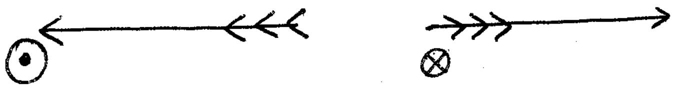
[180°-360°] mechanical degree

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

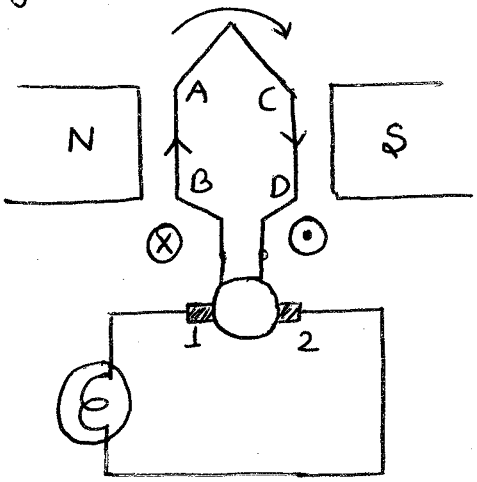
$e = Bl v \sin\theta$

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 :-
Fare Finger → 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

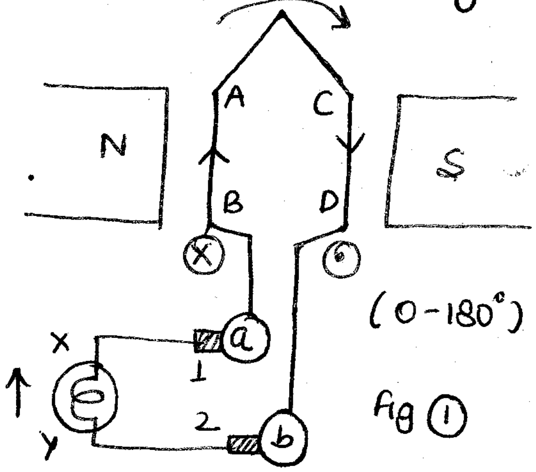
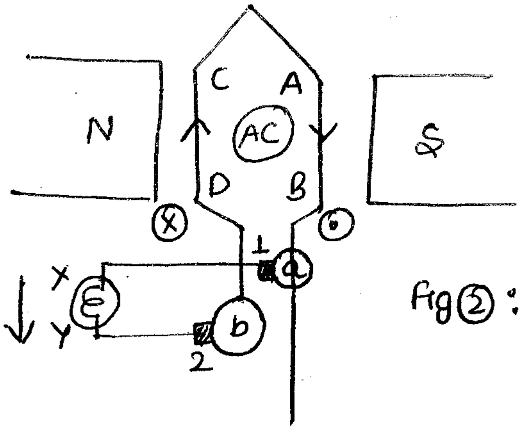


fig ①

current direction : $\underrightarrow{BACD}\, b2\underrightarrow{YX}1aB$



fig②:

current direction: DCABa1XY2bD

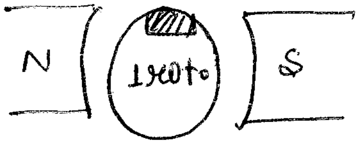
Bidirectional current in coil i.e; AC

in the coil: AC

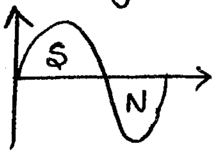
in the bulb: AC

i.e; this is AC generator.

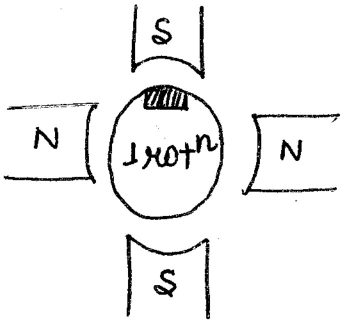
AC is collected as AC when connect two ring or slip ring.

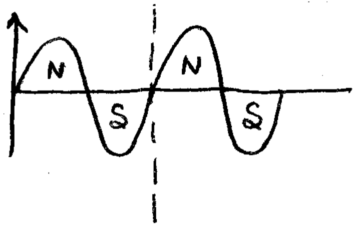


when conductor make one rotation then conductor will pass south pole and then also north pole. so, if south pole produce one pulse then north pole produce opposite. [There is no rule is south pole producing + or -ve & North pole producing +ve or -ve]



with 2pole: 1cycle in one rotation





with 4 pole: 2cycle 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.

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

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

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Electrical Engineering

Toppers Handwritten Notes

13.POWER ELECTRONICS

BY- JAGDISH SIR

Topics:

(i) Power semiconductor devices

(ii) Phase controlled rectifier (AC-DC) and Appl: 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 ($f \uparrow$)
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 ⇄ 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 → DC converters (choppers)

*(iv) switched mode DC → AC converters (inverters)

(v) AC drive

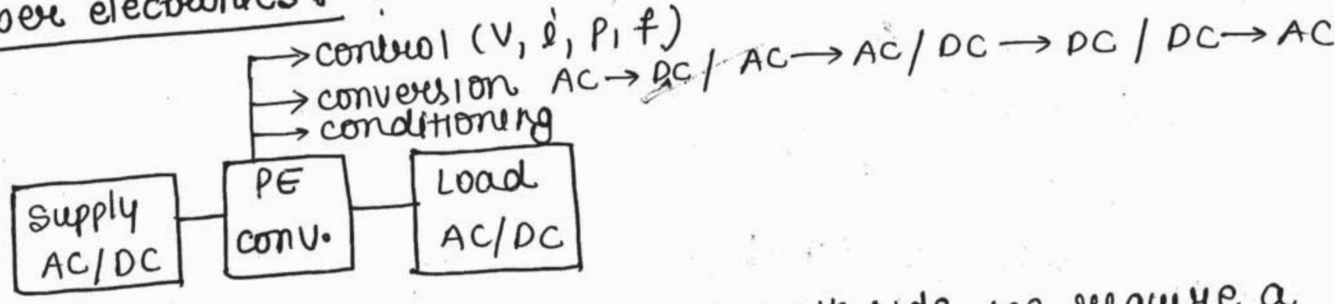
only for ESE

(vi) Resonant converters

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

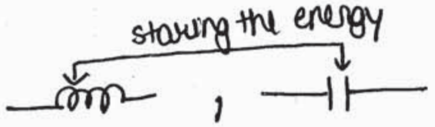
(viii) SMPS

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

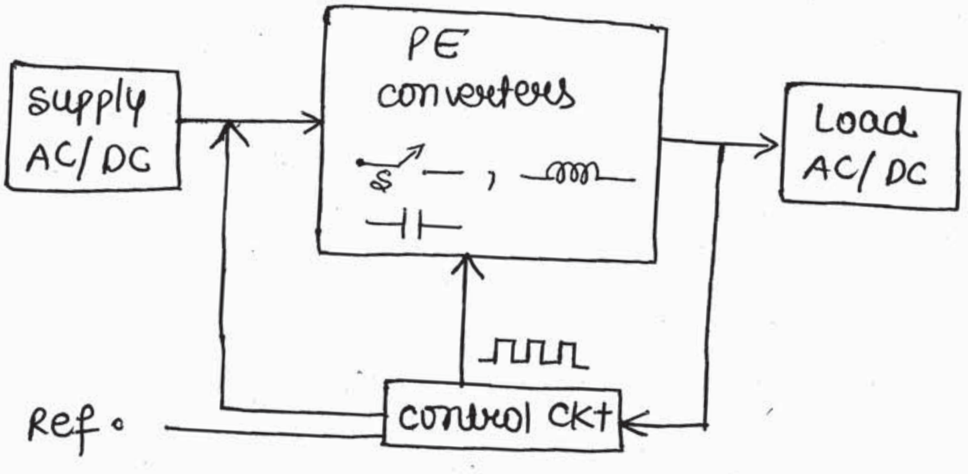


selection of switchs depend on
→ power ratting
→ voltage ratting

freq. ratting.

↳ Not used because power dissipation element.

(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 A —/— K (S) using semiconductor devices & these sc devices should operate with high efficiency. In power electronic, semiconductor devices are mainley 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 : $V_0 \nearrow$, $f_0 \nearrow$
AC → AC

High power & low speed in drive

Semiconductor Switches :-

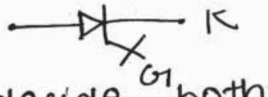
(i) uncontrolled switch : (eg) Diode A —▷|— K , DAIC

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) A —▷|— K (G) , 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

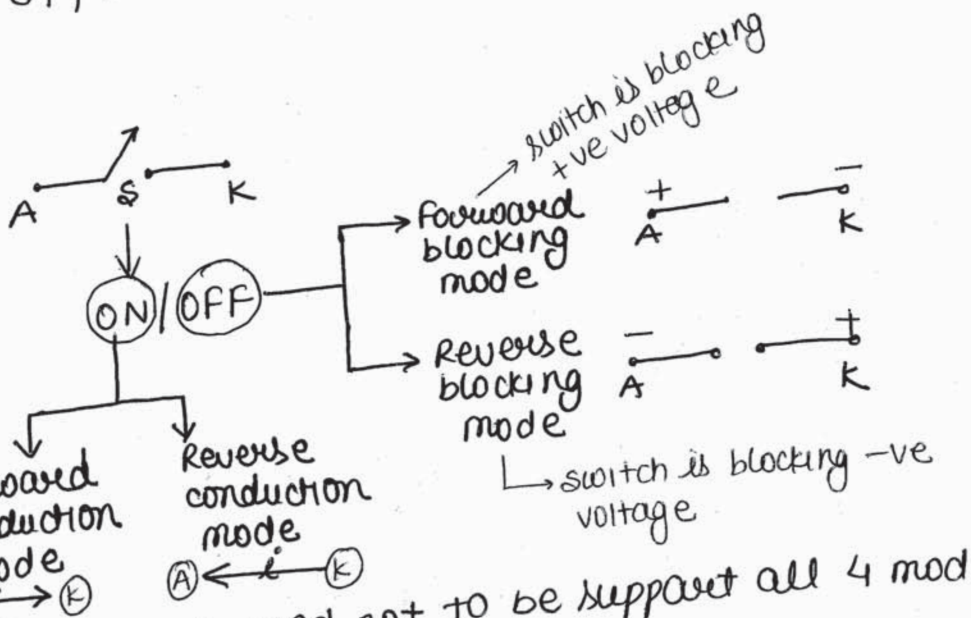
(iii) Fully controlled switches : (eg) GTO



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

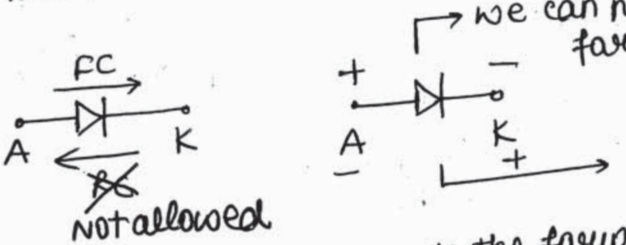
when we give $+I_g$ to Grate terminal then GTO ≡ ON
$-I_g$ to Grate terminal then GTO ≡ OFF

(eg) BJT, MOSFET, IGBT



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

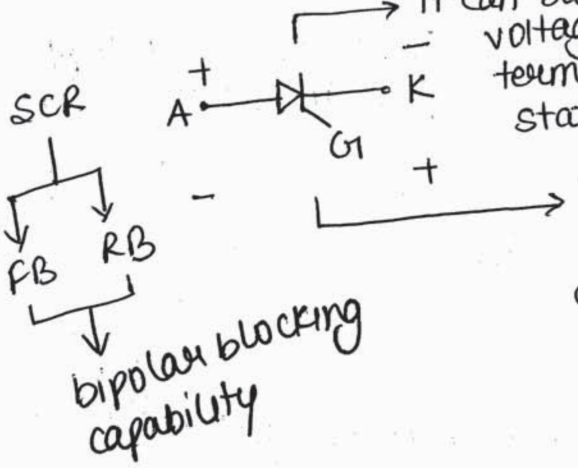
Eg-: Diode



we can not block the forward voltage ~~FB~~

it can block Reverse voltage RB ✓

SCR



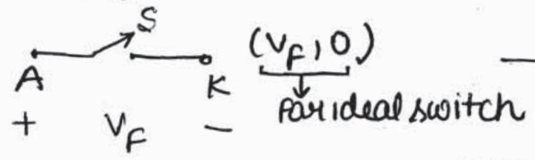
it can block the forward voltage when Grate terminal is in OFF state

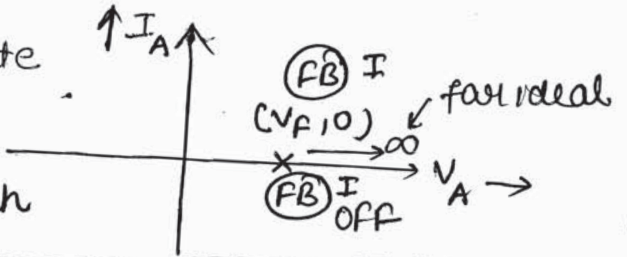
it can block the reverse voltage also when Grate = 0 & current direction is only one way.

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

Foure -mode of an ideal switch :-

(i) Farward blocking mode : i.e, OFF state

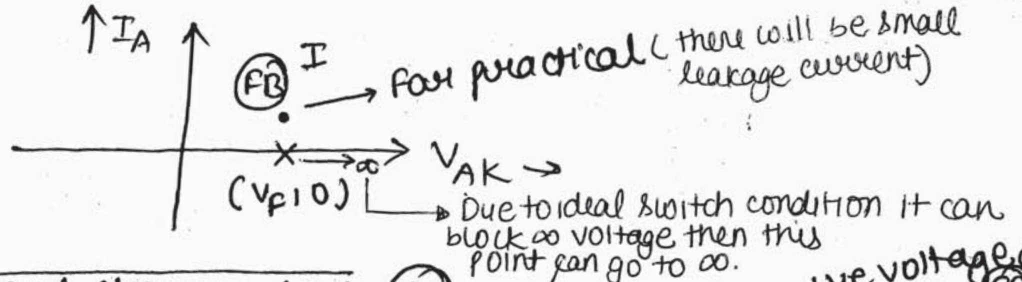




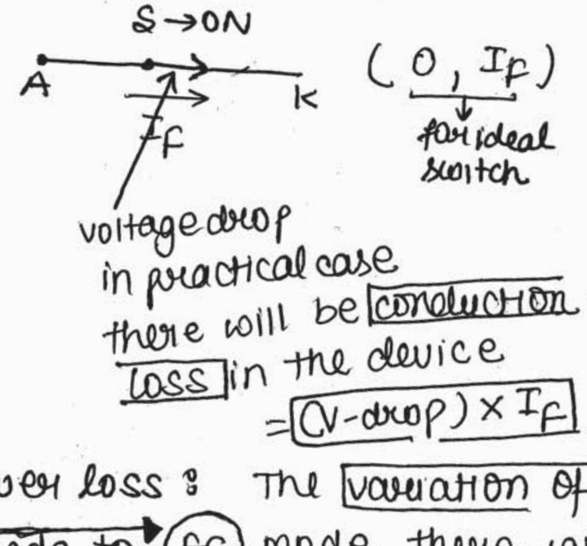
An ideal device when blocking the farward voltage (V_F) then current parsing through the device is zero Amp but in practical some leakage current flow through it due to minority current Now, we are having some losses in semiconductor device even in the OFF state i.e, blocking power loss = [$V_F \times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

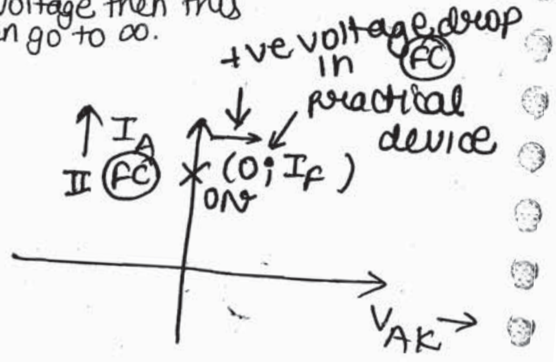
voltage rating : that much maximum voltage semiconductor device can block. [withstand in blocking state]

× → ideal
• → practical



(ii) Farward conduction mode : (FC)



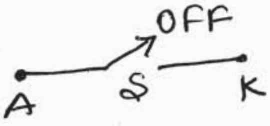


there will be conduction loss in the device $= (V\text{-drop}) \times I_F$ → major loss among all three losses

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) :~

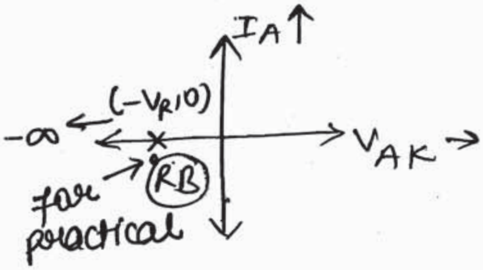


$(V_R, 0)$
(−)

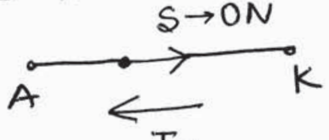
− V_R +

− ∞ +

↳ not possible

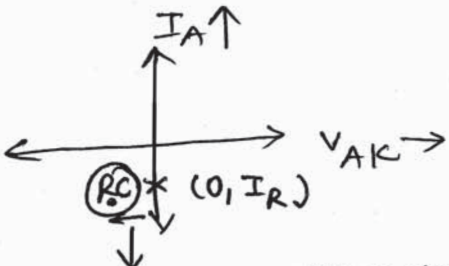


(iv) Reverse conduction mode (RC)



$(0, -I_R)$

(−)
↳ drop is −ve for practical case

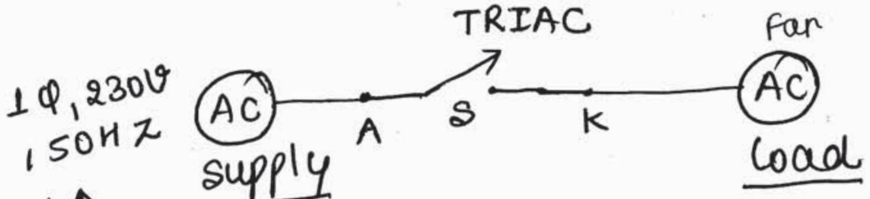


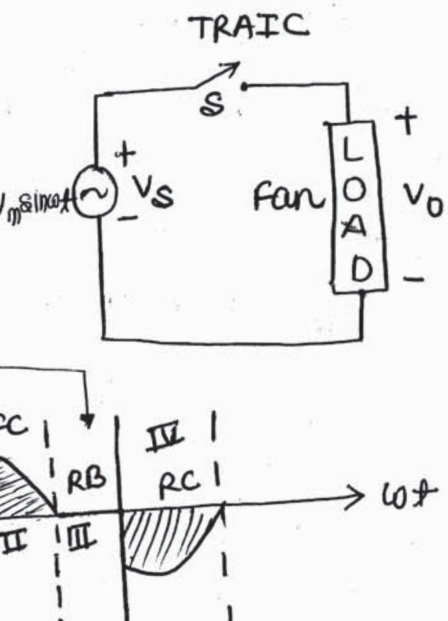
negative voltage drop in (RC)

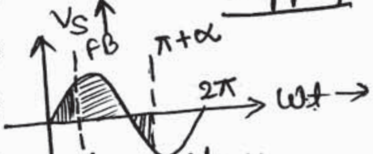
TRAIC supports all the 4 modes

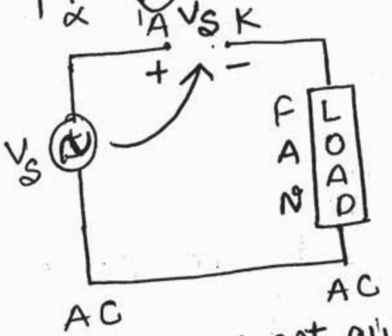
↳ AC → AC converter
in these converter we use that switch which support all the 4 modes.

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

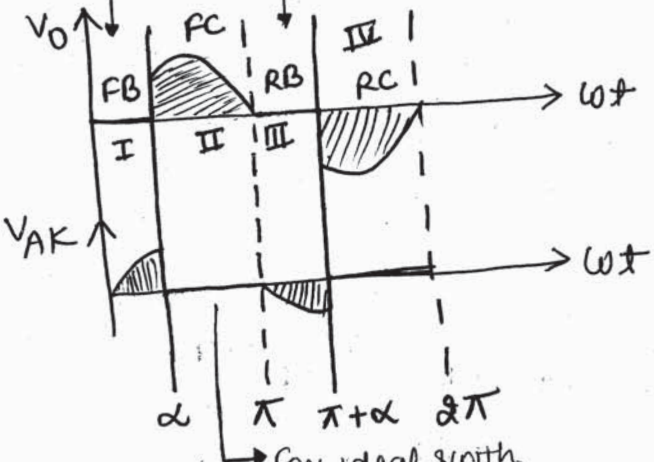








when $I_g = 0$;

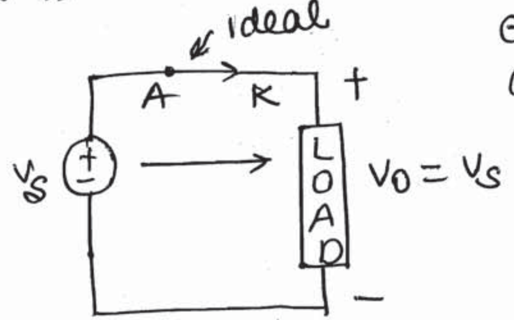


when we are not giving supply to Gate terminal + Then entire voltage appear across the switch. $(V_{AK} = V_S)$ & $V_0 = 0$

↳ FB [let up to α]

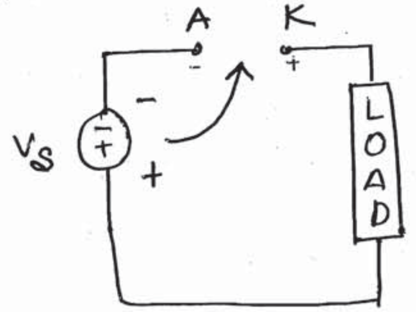
↳ For ideal switch $V_{drop} = V_{AK} = 0$

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

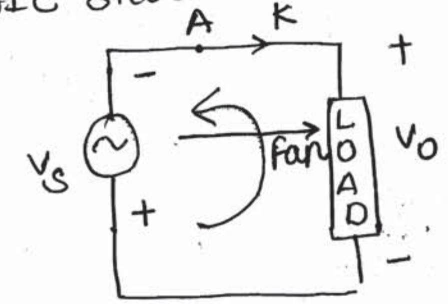


entire supply voltage appears across the load.

(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 in reverse direction the TRAIC start conduction



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 vograph symmetrically 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.

MADE EASY
Electrical Engineering
Toppers Handwritten Notes
14.MEASUREMENT & INSTRUMENTATION
BY- BALAJI SIR

Electrical & Electronic Measurement & Instrumentation

Electrical (gate + IES)

Measurement of V
Measurement of I
Measurement of P
measurement of P.F
mesurement of Energy
(R, L, C) Resistance, Inductance and capacitance
Potentiometer
Instrument transformer

Electronics (GATE + IES)

Q-Meter
Digital meter
CRO
Error Analysis

Instrumentation (IES)

measurement of Non electrical quantities like temp, pressure, flows ...
Data aquisition system

Books

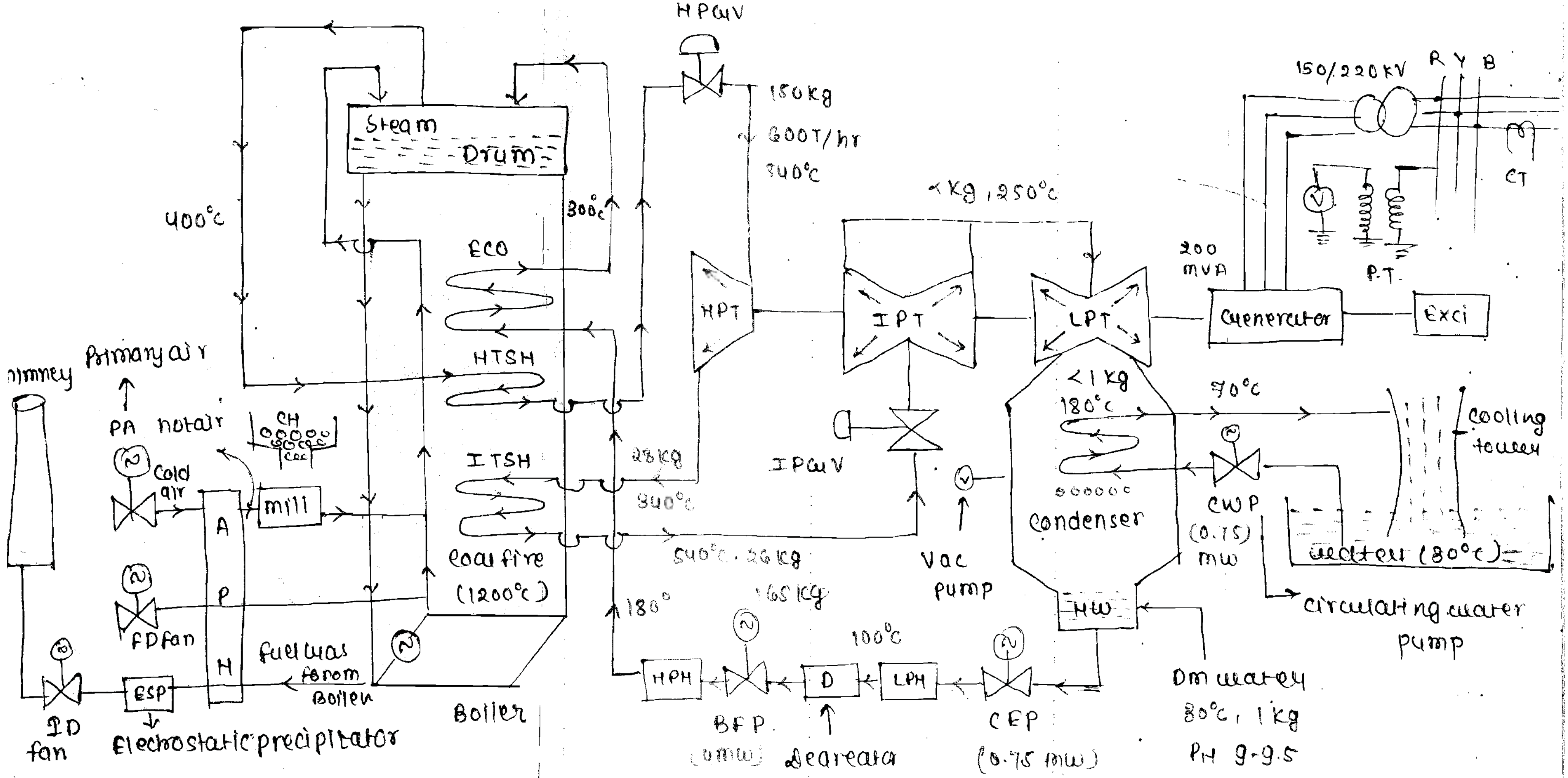
(1) A·K Shawney (Shawney)
(2) Golding
(3) cooper

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 pum
* HPH = High pressure heater (step by step temp ↑ing)
* when coal fire temp arround 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 mechanisam called turboseperator which seprate wate, water and steam.
* HTSH = High temperature super heater (steam will pass & its temp raise to 540°C)
* HPGV = High pressure governing value, IPGV = Intermediate pressure governing value
* 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
* Dearator = Remove dissolved gases
  for improving thermal η economiser is used
* FD fans - sending oxygen to boiler for proper combustion
  (it will take atmospheric air used for proper combustion)
* HW = Hot well


HPωV
150kg
600T/hr
540°C
Steam
Drum
400°C
300°C
ECO
HTSH
ITSH
Coal fire
(1200°C)
Boiler
Primary air
PA hot air
CH
Coal
Cold air
mill
A
P
H
FD fan
fuel was from Boiler
ESP
Electrostatic precipitator
ID fan
nimney
28kg
340°C
540°C, 26kg
180°
165kg
HPT
IPT
LPT
<kg, 250°C
IPωV
Vac pump
HPH
BFP
(6MW)
Dearearata
D
100°C
LPH
CEP
(0.75 MW)
<1kg
180°C
70°C
Condenser
HW
DM water
80°C, 1kg
PH 9-9.5
CWP
(0.75) MW
cooling tower
water (80°C)
circulating water pump
200 MVA
Generator
Exci
P.T.
V
150/220KV
R Y B
CT

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

$= \eta_B \times \eta_T \times \eta_G$

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

90% 30-40% 90%.

now η due to condence heat loss

<u>Bituminous coal used</u>

Coal chemical / heat Energy

= calorific value ⇒ C_F ⇒ Kcal

$$\boxed{860 \text{ kcal Heat energy} = 1 \text{ kwhr elect energy}}$$

<u>Practical</u>

$\eta_{thermal} = 40\%$

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 = 200×10^3 kw × 24 hrs × 1.25 kg

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

<u>(1) C_F in kcal/kg</u>

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

<u>2) C_F is kwhr/kg</u>

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

Analog meter

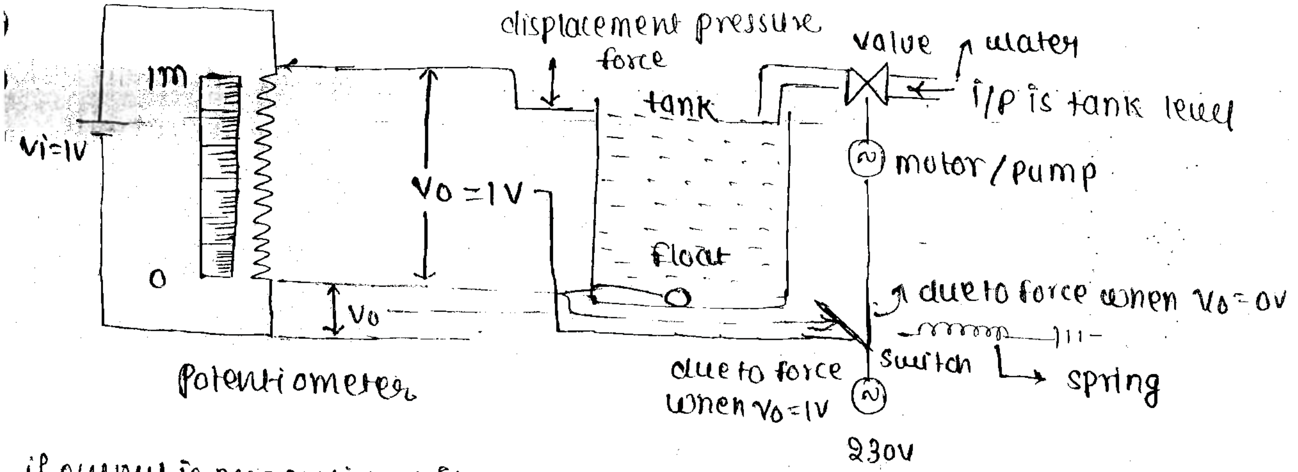
- Measure
  - V
  - I
  - P
  - P.F
  - Energy
- Principals
  - Electro magnetic
  - electrostatic
  - thermal
- Representation
  - Indicating meters
    - Voltmeter (V)
    - ammeter (A)
    - watt meter (W)
  - Integrating meters
    - Energy meter
    - A-hr meter
  - Recording meters
    - Galvanometric
    - potentiometric
  - Null detector
    - 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

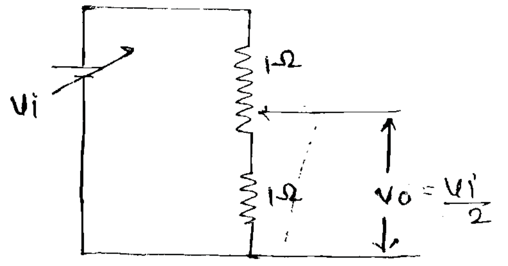
when tank level is full so current will flow creates magnetic field there for switch comes to open position

and when Vo=0V and [illegible] =0 so it will experience force

1m = 1volt

100cm = 1volt

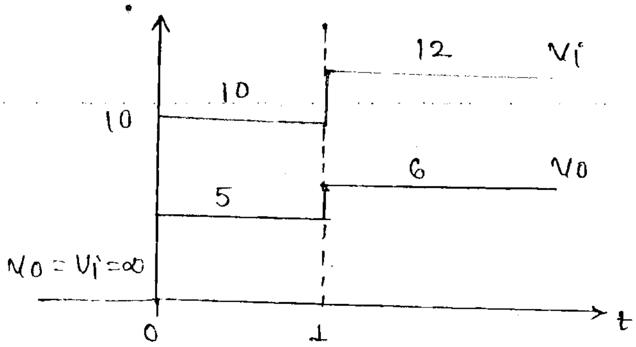
$\boxed{1cm = 0.01 \text{ volt}}$



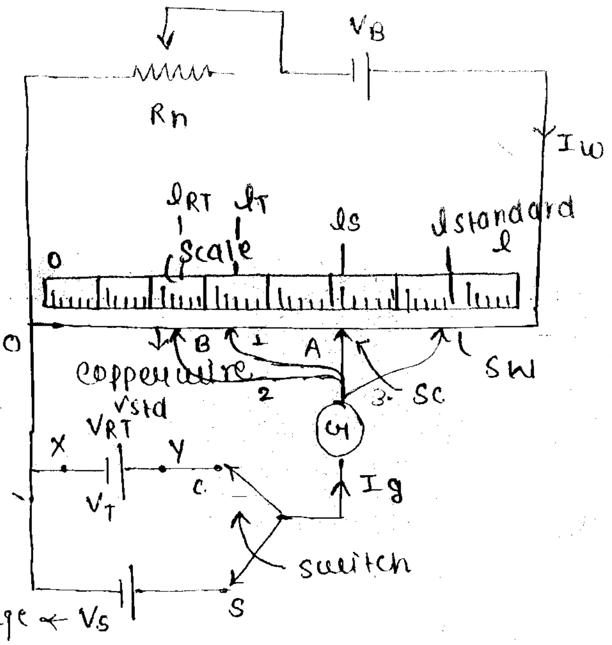
$$T(S) = \frac{V_o}{V_i} = \frac{1}{2} = K$$

= constant

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



Practical potentiometer



(Daniel cell)
standard voltage ← Vs

VB = External Battery

Rn = Rheostat

Iw = working current

l = length of slide wire (m)

r = Resistance of slide wire (Ω/m)

lr = total resistance of slidewire (Ω)

Sw = Slide wire

Sc = Sliding contact / Jockey

Ⓖ = Galvanometer

S = Standarization

C = calibration

Vs = Standard voltage source

VT = test voltage

Convert centimeter scale into voltage called standarisation

Once standarize never change working current

Put galvanometer to make $I_g = 0$

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

EMI (EE)

Application

1. Measurement of V_T:

$$\boxed{\cancel{I_w} = \frac{V_B}{\cancel{R_h} + lr}}$$

switch at S

$$I_w (l_s r) = V_s$$

$$\boxed{\cancel{I_w} = \frac{V_s}{l_s r}} \quad — ①$$

switch at C

$$I_w \, l_T \cdot r = V_T$$

$$\boxed{I_w = \frac{V_T}{l_T \cdot r}} \quad — ②$$

$$① = ②$$

$$\frac{V_s}{l_s r} = \frac{V_T}{l_T \cdot r}$$

$$\boxed{\frac{V_s}{l_s} = \frac{V_T}{l_T}}$$

l_s = length of switch at which V_s is balanced
l_T = length of switch at which V_T is balanced

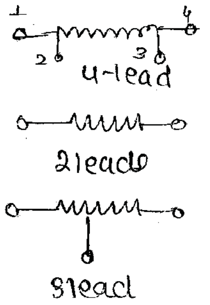
balanced condition means making $I_g = 0$
will take reading when $I_g = 0$ or null therefore potentiometer is called null detector

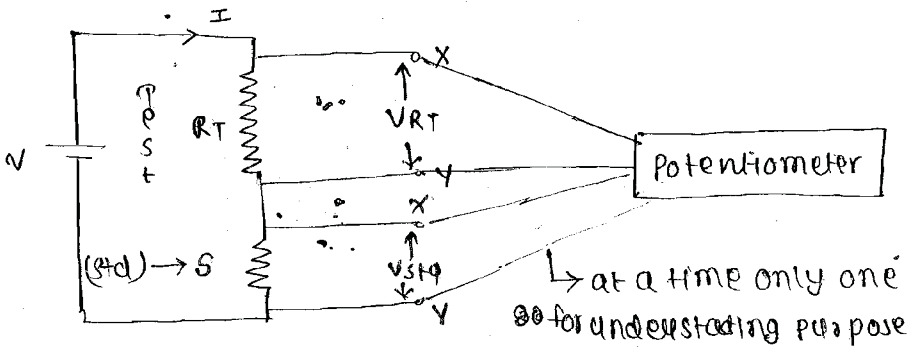
2. Measurement of low Resistance (< 1Ω)

Classification of R

(1) low R — R < 1Ω — T/F, Ⓖ, Ⓜ winding
(2) medium R — 1Ω ≤ R ≮ 100 kΩ — Heater, iron box, electronic equipments
(3) High R — R > 100 kΩ — insulatⁿ cable, Ⓜ, Ⓖ, T/F

Representation





↳ at a time only one X-Y connectⁿ is there so for understanding purpose I have shown both

ENGLISH

Sapna

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gate ○ Critical Reasoning
Inferential Reasoning
Logical deduction

Parajumbles

Reading Comprehension

gate ○ Vocabulary →
- Analogies
- Sentence Completion
- One word Substitutions
- Synonyms.
- Antonyms.

gate ○ Grammar →
- Spotting the Error.
- Sentence Improvement.

Analogy {RelatiOnship}.

Q. Gladiator (warrior) : Arena (Plat form)

a) Dance : Stage
b) Commuter : train
c) Teacher : classroom
d)✓ Lawyer : courtrom

Gladiator
a) performer
b) fighter.
c) opponent
d) End result — win / loose.

(Traveller - Commutator)

Q. frequency [Antonym ?]

a) Periodicity
✓b) Rarity
c) Gradualness
d) presistency (continuity) Perseverance
↓ contineous determinatn.

Q. Children : Pediatrician (child specialist)

a) Adult : Orthopaedist (Borns specialist)
✓b) females : Gynacologist (female specialist)
c) Kidney : Nephrologist (deal with kidney & Urine)
d) Skin : Dermatologist (deal with skin)

Q. Nocturnal : Bat.
(active at night)

✓a) Amphibian : frog → Stay land or water
b) Sly : Cat → Cunning (deceitful)
c) Carniveous : cow → eating flesh)
d) Aquatic : Liz. ↳ Lizard.
↓
(live in water).

5. Xenophobia : foreigners. (~~[illegible]~~ least similar)
Fear of foreigneers & stranfers

a) Bibliophobia : Books
b) Anglophobia : English
c) Hemophobia : Blood
d) Claustrophobia : ~~Height~~ (fear of height is Acrophobia)
↳ (fear of confined or closed spaces) or conjusted place.

Phobia
↓
fear

Mania
↓
obession, (craze)

Clumsy
↓
- dirty, unpleasant
- unskilled

Vibrant (full of happyness, Energy)

~~Cheerfull~~
~~depressed~~

Synonyms.	Antonyms.
Lively	Lazy
Vivacious	Lethargic
Vigourous	Sluggish.
Enthusiastic	↳ slow & Inactive
Energetic	Dormant.
Passionate	Indolement.
Zealous.	Dizzy
Zestful	Drowsy
Exuberant.	↳ Sleepy
Active.	Lackadaisical

Fatique
↳ tiredness.

MADE EASY

IES/GATE/PSUs

Toppers Handwritten Notes

REASONING AND APTITUDE

By-Dheeraj Parasar Sir

* NUMBER SYSTEM :-

V → Viniecullum (BAR)
B → Bracket . {}
O → of.
D → Division. (÷)
M → Multiplication (x)
A → Addition . (+)
S → substraction (-)

Q1) Convert the following recurring forms into their corresponding p/q forms ?

a) $27.\overline{17}$ ↓ Complete Bar

$27.171717\cdots$

(Bar Immedialely after point).

b) $27.2\overline{17}$ ↓ Partial Bar

$27.21717\cdots$

c) $0.00\overline{17}$ ↓ Partial Bar

$0.00171717\cdots$

Soln:. a) $27.\overline{17}$

$$x = 27.171717\cdots$$
$$100x = 2717.1717\cdots$$
$$100x - x = ~~27~~\ 2717.1717 - 27.1717$$
$$99x = 2690$$
$$\boxed{x = \frac{2690}{99}}$$

SHORTCUT

$$x = 27.\overline{17}$$
$$p/q = \frac{2717 - 27}{\underline{99}}$$
$$= \frac{2690}{\underline{99}}$$

b) $27.2\overline{17}$

$$x = 27.21717\cdots$$
$$\frac{p}{q} = \frac{27217 - 272}{\underline{9}\,\underline{9}\,\underline{0}}$$
$$\boxed{\frac{p}{q} = \frac{26945}{990}}$$

c) $0.00\overline{17}$

$$\frac{p}{q} = \frac{00017 - 000}{9900}$$
$$\boxed{\frac{p}{q} = \frac{17}{9900}}$$

Q2) $27.\overline{27} \times 33 + 6$

Soln:. $\frac{(2727-27)}{\cancel{99}\,3} \times \cancel{3}3 + 6$

$= \frac{2700\cancel{\times 3}}{3} + 6$

$=$ [illegible] 906.

Q3) What is the unit's digit in the expansion of a) $(766)^{136}$.

- b) $(277)^{134}$.
- c) $(454)^{41}$.
- d) $(888)^{103}$.
- e) $(1028)^{100}$.
- f) $(459)^{40}$.

Soln:. a) $(766)^{136}$ ← Based on cyclicity or Power cycle →

$0^N = 0$

$1^N = 1$

$2^N =$

$2^1 = 2$

$2^2 = 4$

$2^3 = 8$

$2^4 = 16$

$2^5 = 32$

$2^6 = 64$

$2^7 = 128$

$2^8 = 256$

$2^9 = 512$

→ cyclicity of 2^N is 4 ie 2, 4, 8, 6

3^N ← cyclicity is ~~[illegible]~~4 ie (3, 9, 7, 1)

$3^1 = 3$

$3^2 = 9$

$3^3 = 27$

$3^4 = 81$

$3^5 = 243$

$3^6 = 729$

3^7

4^N ← cyclicity is (4, 6)

$4^1 = 4$

$4^2 = 16$

$4^3 = 64$

$4^4 = 256$

$4^5 = 1024$

NUMBERS	FREQN OF NOS. as POWER CYCLE
0, 1, 5, 6	STAY AS IT IS
2, 3, 7, 8	4
4, 9	2

~~a) (766)~~^{136} ~~→ unit digit = 6.~~

~~b) (277)~~^{134} ~~→ 4~~

c) ~~(454)~~$^{\cancel{134}\,41}$ ~~→ 2~~

d) ~~(888)~~^{103} ~~→ 4.~~

a) $(766)^{136} = 766 \times 766 \times 766 \times 766 \times \text{-----}$ 136 times.

$= \text{---}6 \times \text{---}6 \times \text{---}6 \times \text{--}6 \times \text{----}$

$= \text{-------}6$

$$\boxed{(\text{------}0/1/5/6)^{\alpha\alpha\alpha\alpha\text{----}\alpha} = \text{------}0/1/5,6}$$

b) $(277)^{134} = 277 \times 277 \times 277 \times 277 \times \text{----}$ 134 times.

$= \text{---}7 \times \text{---}7 \times \text{---}7 \times \text{----}7 \times \text{-----}$ 134 times.

(....) × (....) × (....) × .... × (277 × 277)

49

↓

units digit is (9)

33 ← Complete sections.

$4\overline{)134}$

12

14

12

×2

Short cut :

$(27\textcircled{7})^{134} \longrightarrow$ Power cycle = 4

$4\overline{)134}$ 33

12

×14

12

×2

$7^2 = 4\textcircled{9}$

↓

units place (units digit)

$*(454)^{41} \longrightarrow$ Power cycle = $\cancel{0}2$

$$\begin{array}{r|l} & 20 \\ 2 & 41 \\ & 40 \\ \hline & \times 1 \end{array}$$

$4^1 = 4$

$*\ (888)^{103} \longrightarrow$ Power cycle = 4

$$\begin{array}{r|l} & 25 \\ 4 & 103 \\ & 100 \\ \hline & 3 \end{array}$$

$8^3 = 512$

$*\ (1028)^{100} \longrightarrow$ Power cycle = 4

$$\begin{array}{r|l} & 25 \\ 4 & 100 \\ & 100 \\ \hline & 000 \leftarrow \text{Remainder} \end{array} \qquad \times$$

$8^0 = 1$

$*\ (459)^{40} \longrightarrow$ Power cycle = 2

Remainder = 0

*Special case of Remainder zero:-

- * All complete sections.
- * No incomplete section.

$(1028)^{100} \longrightarrow$ P.C = 4

$$\begin{array}{r|l} & 25 \\ 4 & 100 \\ & 100 \\ \hline & \times\times\times \\ & 0 \end{array}$$

$$8^4 = 8^2 \times 8^2$$
$$= 64 \times 64$$
$$= \ldots\ldots 6$$

~~40~~ $(459)^{40} \longrightarrow$ P.C = 2

$$\begin{array}{r|l} & 20 \\ 2 & 40 \\ & 40 \\ \hline & 00 \end{array}$$

$9^2 = 9 \times 9 = 81$

* Remainder 0 short cut:-

After getting Remainder = 0 → Even Base = 6
→ odd Base = 1

Q4) What is the unit's digit in the expansion of the following expression:-

$$(666)^{666} \times (877)^{134} + (959)^{20}$$

$$\begin{array}{r|l} & 33 \\ 4 & 134 \\ & 132 \\ \hline & 2 \end{array} \qquad 7^2 = 49$$

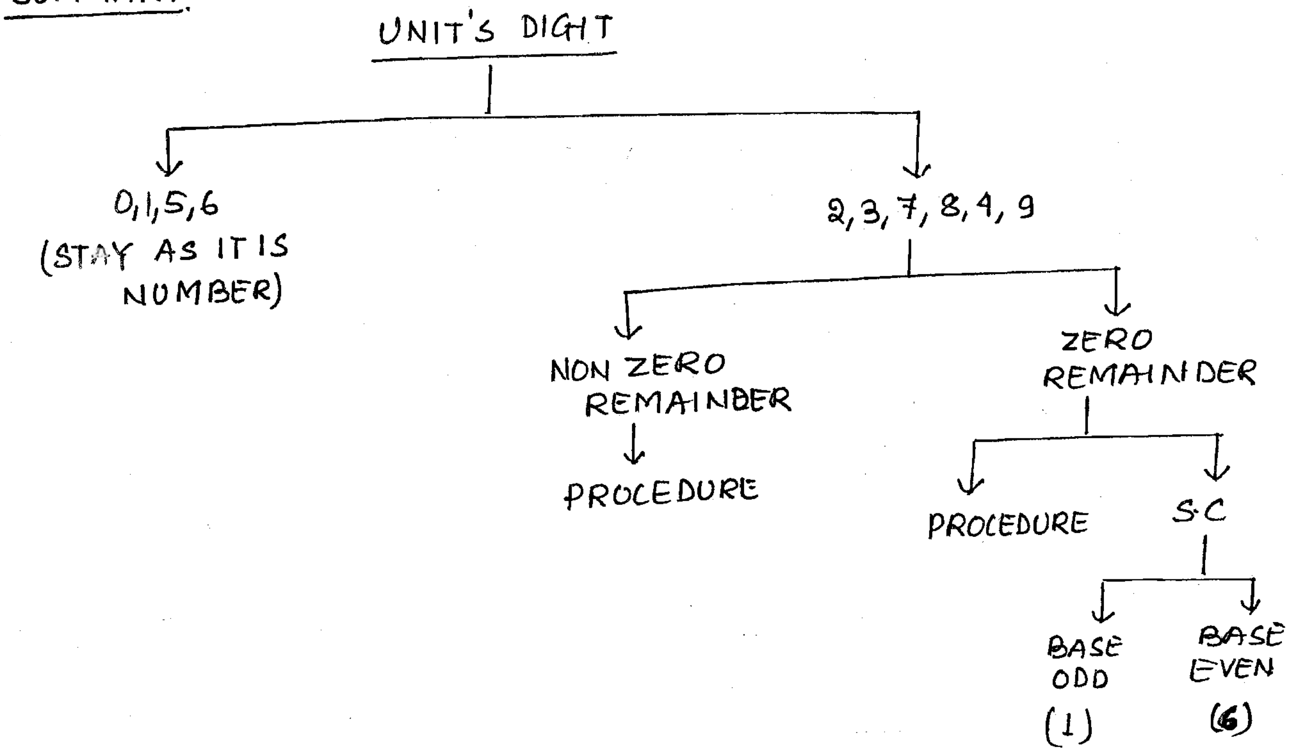
$$\begin{array}{r|l} & 5 \\ \cancel{8}4 & 20 \\ & 20 \\ \hline & 00 \end{array}$$

(959) → odd Base = 1

Soln:- $(\ldots\ldots 6 \times \ldots\ldots 9) + \ldots\ldots +1$

$= (\ldots\ldots 4) + (\ldots\ldots 1) = \ldots\ldots 5$

SUMMARY



Q5) How many zeroes are there at last in the expansion of

a) $25 \times 4 \times 8 \times 7 \times 10 \times 16 \times 100$

b) $(25)^{125} \times 4^{40}$

Soln:. a) $25 \times 4 \times 8 \times 7 \times 10 \times 16 \times 100$

$100 \times 56 \times 16 \times 1000$

$= 56 \times 16 \times 100000$

$5^2 \times 2^2 \times 2^3 \times 7 \times 5 \times 2 \times 2^4 \times 2^2 \times 5^2$

$= 2^{12} \times 5^{5} = 2^7 \times 2^5 \times 5^{5}$ least power

LEAST POWER

$= 2^7 \times 10^5$

= 5 ZEROS

b) $(25)^{125} \times (4)^{40}$

$(5)^{250} \times 2^{80}$ LEAST POWER

80 ZERO

Note:. $7^{125} \times 4^{50}$

$7^{125} \times 2^{100}$

NO ZEROS

ZERO'S AT LAST CONDITION :.

i) Multiple of 10. → direct mutiple ie 10,100,1000----

ii) Hidden multiple → (2, 5)

*The total no. of (2×5) combinations = no. of zeros at last in the expansion

(total no. of (2×5) combn) = (no. of zeroes at last in expansion)

Q6) How many zeros are there at last in the expansion of :.

a) 6!
b) 10!
c) 100!
d) 145!
e) 1000!

Note :.

1! ; 2! = 2 ; 3! = 6; 4! = 24

$\boxed{5! = 120}$

↓ onwards only zeros will start coming not before that.

Solⁿ :. a) 6! $= 6 \times 5 \times 4 \times 3 \times 2 \times 1$

$= 6 \times 5^1 \times 3 \times 2^3$

= 1 ZERO.

↙ 720

b) 10! $= 10 \times 9 \times 8 \times 7 \times 6 \times 5 \times 4 \times 3 \times 2 \times 1$

$= 2 \times 5 \times 9 \times 2^3 \times 7 \times 3 \times 2 \times 5 \times 2^2 \times 3 \times 2 \times 1$

$- 2^8 \times 5^2$

= 2 ZEROS

↙ (3628800)

c) 100!

↓

100 → 20×5
95 → 19×5
90 → 18×5
85 → 17×5
80 → 16×5
75 → 15×5 = 3×5×5
70 → 14×5
65 → 13×5
60 → 12×5
55 → 11×5
50 → 10×5 = 2×5×5
45 → 9×5
40 → 8×5
35 → 7×5
30 → 6×5
25 → 5×5
20 → 5×4
15 → 3×5
10 → 2×5
5 → 1×5

Note :. For 100! Zeroes are by default. They will come by default. and no. of zeroes depends on no. of 5's present in it.

$100! = 1 \times 2 \times 3 \times 4 \times \textcircled{5} | \times 6 \times 7 \times 8 \times 9 \times \overset{2\times5}{\textcircled{10}} | \times 11 \times 12 \times 13 \times 14 \times \overset{3\times5}{\textcircled{15}} | \times 16 \times 17 \times 18 \times 19 \times \overset{4\times5}{\textcircled{20}} | \times ----$

$\times ---- \times 100$

~~$\frac{100}{5}$~~ $\frac{100}{5}$ = 20 sections ← divide the complete 100! in 20 sections.

* In these sections some special nos (which contain 2 5's will also be there). such as :.

Already taken into account in dividing sections.

25 → 5 × ⑤
50 → 5 × ⑤ × 2
75 → ~~2~~ 5 × ⑤ × 3
100 → 5 × ⑤ × 4

(NOT TAKEN INTO ACCOUNT in 20 SECTIONS) ⟶ NOW taking $= \left(\frac{100}{5} + \frac{100}{25}\right) = 24.$

MADE EASY
IES/GATE/PSUs
Toppers Handwritten Notes
MATHEMATICS
By-RAMU MALADI Sir

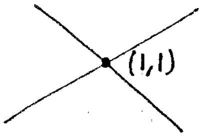
*LINEAR ALGEBRA :.

Analysis

$x+2y=3$
$2x+3y=5$

so, $x=1, y=1$

Intersecting Line



(x' and y')

$x+2y=3$
$2x+4y=6$

let $y=K$
$x=3-2K$

Infinite no. of solutions

COINCIDENT LINE

$x+2y=3$
$x+2y=5$

NO solution

(PARALLEL LINES)

*Any 1st degree 2 dimensional equation in $x+y$ represents a line in the XY PLANE. (LINEAR SYSTEM OF EQUATION IN 2 VARIABLES)

Note :.

*The study of LINEAR SYSTEM OF EQUATIONS is called LINEAR ALGEBRA.

$x+2y=3$
$2x+3y=5$

on solving the equation

$x=1; y=1$

(UNIQUE SOLUTION)

$x+2y=3$
$2x+4y=6$

let $y=K$
$x=3-2K$

(INFINITE NO. OF SOLUTION)

$x+2y=3$
$x+2y=5$

(NO SOLUTION)

*To study about the Linear system of equations, we require the concept "RANK OF MATRIX." Hence we study about MATRICES in the concept LINEAR ALGEBRA.

*MATRIX :.

*Arrangement of elements or numbers in Rows and columns such that each row will have same no. of element and each column will have same no. of element is called a MATRIX.

*Operation on Matrixes:

1) Addition
2) Substraction
3) Multiplication $\{A_{m\times l} \times B_{l\times n} = C_{m\times n}\}$

4) TRACE OF SQUARE MATRIX:

*The sum of the PRINCIPAL DIAGONAL ELEMENTS OF A SQUARE MATRIX is called TRACE.

5) SYMMETRIC MATRIX:

When $\boxed{A^T = A}$

$$\begin{bmatrix} 1 & 5 & -1 \\ 5 & 2 & 9 \\ -1 & 9 & 3 \end{bmatrix}$$

the matrix A is ~~skew~~ symmetric

6) SKEW SYMMETRIC MATRIX:

When $\boxed{A^T = -A}$.

COMPULSORY CONDITION (diagonal elements should be zero)

$$\begin{bmatrix} 0 & 3 & -5 \\ -3 & 0 & 9 \\ 5 & -9 & 0 \end{bmatrix}$$

then Matrix A is SKEW SYMMETRIC.

*DETERMINANT OF SQUARE MATRIX:

*For a 1X1 MATRIX, the no. itsey is the Determinant

*For a 2X2 MATRIX of the form:

$$\begin{bmatrix} a & b \\ c & d \end{bmatrix}$$

the determinant is given by. $(ad-bc)$

*MINOR OF AN ELEMENT:

let
$$\begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix}$$

then Minor of $a_{11} = \begin{vmatrix} a_{22} & a_{23} \\ a_{32} & a_{33} \end{vmatrix} = (a_{22}a_{33} - a_{32}a_{23})$

Minor of $a_{21} = \begin{vmatrix} a_{12} & a_{13} \\ a_{32} & a_{33} \end{vmatrix} = (a_{12}a_{33} - a_{32}a_{13})$

*COFACTOR of an Element :-

*Minor of a_{ij} is M_{ij} ; then cofactor of a_{ij} is

$$\boxed{\text{cofactor of } a_{ij} = (-1)^{i+j} \cdot M_{ij}}$$

*The Determinant of square matrix is defined as " The sum of product of elements of any row or any column with the corresponding cofactors"

*Analysis :-

let
$$A = \begin{bmatrix} 1 & 0 & 2 & 1 \\ 1 & 0 & 1 & -1 \\ 1 & 2 & 3 & 1 \\ 1 & 0 & 2 & 0 \end{bmatrix}$$

*we have to find the determinant of given 4x4 matrix. For this choose any row or column having the max^m no. of Zeroes.

using 2nd column weget :-

$$2(-1)^{3+2}\begin{vmatrix} 1 & 2 & 1 \\ 1 & 1 & -1 \\ 1 & 2 & 0 \end{vmatrix}$$

$$-2\{1(0+2) - 2(0+1) + 1(2-1)\}$$

$$= -2$$

using 4th column weget

$$1.(-1)^{4+1}\begin{vmatrix} 0 & 2 & 1 \\ 0 & 1 & -1 \\ 2 & 3 & 1 \end{vmatrix} + 2(-1)^{4+3}\begin{vmatrix} 1 & 0 & 1 \\ 1 & 0 & -1 \\ 1 & 2 & 1 \end{vmatrix}$$

$$-1\{-2(2)+1(-2)\} - 2\{1(+2)+1(2)\}$$

$$+6-8$$
$$= -2$$

$$= -2$$

Note :-

*A matrix is said to be NON ~~SON~~ SINGULAR when

$$\boxed{DET(A) \neq 0}$$

and is said to be SINGULAR when

$$\boxed{DET(A) = 0}$$

** $\boxed{Det(AB) = (Det A)(Det B)}$

** Det (A+B) is not necessarily (Det A) +(Det B)

** If any two rows are same or constant multiples (columns) then Determinant of that Matrix is Zero.

** If ~~some~~ SUM of the elements in every row or every column is Zero then the determinant of such matrix is Zero.

for eg.

$$\begin{bmatrix} 1 & 2 & -3 \\ 0 & 2 & -2 \\ 1 & 1 & -2 \end{bmatrix}$$ sum of Rows zero. (sum of each row is zero).

*ADJOINT OF SQUARE MATRIX :.

*It is the Transpose of cofactor Matrix ie

if $A = \begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix}$

then the cofactor of $a_{ij} = A_{ij}$

then $\text{Adj} A = \begin{bmatrix} A_{11} & A_{21} & A_{31} \\ A_{12} & A_{22} & A_{32} \\ A_{13} & A_{23} & A_{33} \end{bmatrix}$

Note :.

* when ** $\boxed{A(\text{adj} A) = (\det A) I}$ $I \to$ Identity matrix.

* ** $\boxed{\det(\text{adj} A) = (\det A)^{n-1}}$; n= order of matrix

*) ** $\boxed{\text{Adj}(\text{adj} A) = (\det A)^{n-2} A}$

*INVERSE of SQUARE MATRIX :-

* A matrix B is said to be Inverse of a Non singular matrix A if ** $\boxed{AB = BA = I}$

*To find A^{-1} we have

** $\boxed{A^{-1} = \frac{\text{Adj} A}{\text{Det} A}}$

*for Matrix A ; $A = \begin{bmatrix} a & b \\ c & d \end{bmatrix}$

** $\boxed{A^{-1} = \frac{1}{ad-bc} \begin{bmatrix} d & -b \\ -c & a \end{bmatrix} \; ; \; \boxed{ad-bc \neq 0}}$

** * $\boxed{\det(A^{-1}) = \frac{1}{(\det A)}}$

*ELEMENTARY TRANSFORMATION ON A MATRIX:.

*There are only 3 elementary transformations; they are:.

✓1) Interchanging of any two rows $(R_1 \leftrightarrow R_2)$

✓2) Multiplication of a row by a constant $(R_2 \to 3R_2)$

✓3) Addition of 1 ROW to the corresponding elements of some other row $(R_2 \to R_2 + R_1)$.

Note:.

$$\left.\begin{array}{l} * R_2 \to R_2 + 3 \\ * R_2 \to R_2 \times R_1 \end{array}\right\} \text{Not elementary xmation.}$$

*Inverse of Matrix (using elementary xmation)

*GAUSS JORDAN METHOD:.

Q1) Find the Inverse of

$$A = \begin{bmatrix} 1 & 3 & 3 \\ 1 & 4 & 3 \\ 1 & 3 & 4 \end{bmatrix}$$

Use this element to make all the elements below/above this as zero.

Soln:

$$\left[\begin{array}{ccc|ccc} \underline{\textcircled{1}} & 3 & 3 & 1 & 0 & 0 \\ 1 & 4 & 3 & 0 & 1 & 0 \\ 1 & 3 & 4 & 0 & 0 & 1 \end{array}\right]$$

$(R_2 \to R_2 - R_1)$; $[R_3 \to (R_3 - R_1)]$

$$\left[\begin{array}{ccc|ccc} 1 & 3 & 3 & 1 & 0 & 0 \\ 0 & \underline{\textcircled{1}} & 0 & -1 & 1 & 0 \\ 0 & 0 & 1 & -1 & 0 & 1 \end{array}\right]$$

$(R_1 \to R_1 - 3R_2)$

$$\left[\begin{array}{ccc|ccc} 1 & 0 & 3 & 4 & -3 & 0 \\ 0 & 1 & 0 & -1 & 1 & 0 \\ 0 & 0 & \underline{\textcircled{1}} & -1 & 0 & 1 \end{array}\right]$$

$R_1 \to R_1 - 3R_3$

$$\left[\begin{array}{ccc|ccc} 1 & 0 & 0 & 7 & -3 & -3 \\ 0 & 1 & 0 & -1 & 1 & 0 \\ 0 & 0 & 1 & -1 & 0 & 1 \end{array}\right]$$

Hence,

$$\boxed{A^{-1} = \begin{bmatrix} 7 & -3 & -3 \\ -1 & 1 & 0 \\ -1 & 0 & 1 \end{bmatrix}}$$

(Q2) Find the inverse of $A = \begin{bmatrix} 1 & 0 & 0 & 3 \\ 0 & 1 & 0 & -2 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$

Soln:. By Gauss Jordan method:.

$$\left[\begin{array}{cccc|cccc} 1 & 0 & 0 & 3 & 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & -2 & 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 1 \end{array}\right]$$

$(R_1 \to R_1 - 3R_4)$; $(R_2 \to R_2 + 2R_4)$

$$\left[\begin{array}{cccc|cccc} 1 & 0 & 0 & 0 & 1 & 0 & 0 & -3 \\ 0 & 1 & 0 & 0 & 0 & 1 & 0 & 2 \\ 0 & 0 & 1 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 1 \end{array}\right]$$

so,

$$\boxed{A^{-1} = \begin{bmatrix} 1 & 0 & 0 & -3 \\ 0 & 1 & 0 & 2 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}}$$

*MINOR OF A MATRIX:.

*For finding the No. of minors of given order choose no. of rows or columns from given no. of Rows or Columns.

let

$$A = \begin{bmatrix} a_1 & b_1 & c_1 & d_1 & e_1 \\ a_2 & b_2 & c_3 & d_2 & e_2 \\ a_3 & b_3 & c_3 & d_3 & e_3 \\ a_4 & b_4 & c_4 & d_4 & e_4 \end{bmatrix}_{4\times 5}$$

Note:.

(4x4) ✓No. of minors of order 4 is 5. $(\underset{\uparrow}{\overset{\text{choosing any Row.}}{}}{}^4C_4 \times \overset{\text{choosing any columns.}}{\downarrow}{}^5C_4 = 5)$

(3x3) ✓No. of minors of order 3 is ${}^4C_3 \times {}^5C_3 = 4 \times 10 = 40$ (choose any 3 rows or columns)

(2x2) ✓No. of minors of order 2 is ${}^4C_2 \times {}^5C_2 = 6 \times 10 = 60$ (choose any 2 rows or colums).

(1x1) ✓No. of minors of order 1 is $4 \times 5 = 20$.

*In general, for matrix $A_{m\times n}$:.

i) The no. of minors of order 'r' that can be generated is $\underline{({}^nC_r \times {}^mC_r)}$.

ii) The order of greatest minor that can be obtained for this matrix is min (m,n).
$\left\{\begin{array}{l} A_{5\times 2} \Rightarrow A_{2\times 2} \to \text{greatest minor} \\ A_{3\times 7} \to A_{3\times 3} \to \text{greatest minor} \end{array}\right\}$ No $(A_{3\times 3})$. No $(A_{4\times 4})$.

RANK OF A MATRIX :.

*Exists for both square as well as Rectangular matrix.

*A no. "r" is said to be the "RANK OF A MATRIX A" if :.

i) there exist a minor of order "r" of A which is not zero.

ii) all minors of order more than "r" of A must be zero.

*Note :. For given 3x3 matrix, the Minor of 3rd order is the given matrix itself. Also the det. of given minor is zero. Hence, also no. other minor of order 4x4 is available. Hence the matrix A cannot have $\rho(A)=3$. Hence we need to search for 2x2 minor and check for availability of such minor whose det $\neq 0$.

for eg :.

$$A = \begin{bmatrix} 1 & 2 & 3 \\ 2 & 4 & 6 \\ 3 & 6 & 10 \end{bmatrix}$$

*All red dotted minors A > have det = 0.
*Green dotted minor donot have det = 0.

then $\det A = 0$

and $\det \begin{bmatrix} 4 & 6 \\ 6 & 10 \end{bmatrix} \neq 0 \Rightarrow 40-36 = 4$

Hence, there exist a minor of order 2x2 whose det is not zero. Hence

$$\boxed{\begin{aligned} \text{Rank} &= 2 \\ \rho(A) &= 2 \end{aligned}}$$

← Rank of Matrix can also be defined as the order of Largest non zero minor of the matrix (Here 2x2 minor).

Note :.

*To find the Rank of the matrix we can use ELEMENTARY XMATIONS.

*By converting, the given matrix into its "ECHELON FORM"; "the no. of NON ZERO ROWS in the "ECHELON FORM IN THE MATRIX" represents the rank of the matrix."

Note :. Calculation of Rank through Minor calculation is very time taking. Hence we use Rank calculation through "ECHELON FORM."

*ECHELON FORM :.

*By applying Elementary Transformations we can convert a given matrix into a form in which :.

i) All zero Rows must be present below Non zero Rows.

ii) In the Non zero Rows; the no. of zeroes before the 1st non zero no. to the next row must increase.

*Such a Form is called "ECHELON FORM OF GIVEN MATRIX".

Q3) Find the Rank of :.

$$A = \begin{bmatrix} -2 & -1 & -3 & -1 \\ 1 & 2 & 3 & -1 \\ 1 & 0 & 1 & 1 \\ 0 & 1 & 1 & -1 \end{bmatrix}$$

*Note :. Going through MINOR calculations to obtain RANK OF MATRIX is time taking. Hence ECHELON FORM FORMATION is used to calculate the Rank of A MATRIX

$\boxed{\rho(A) = \text{RANK of MATRIX } A}$

$$A = \begin{bmatrix} \underline{-2} & -1 & 3 & -1 \\ 1 & 2 & 3 & -1 \\ 1 & 0 & 1 & 1 \\ 0 & 1 & 1 & -1 \end{bmatrix}$$

$R_2 \rightarrow 2R_2 + R_1$

$R_3 \rightarrow 2R_3 + R_1$

* NO Zeroes before (-2)

*1 Zero before 3. Hence no. of Zero increased from going from 1st row to 2nd row.

*1 Zero before (-1) hence no increase in no. of Zero from 2nd to 3rd Row. Hence not in ECHELON FORM.

$$\begin{bmatrix} -2 & -1 & -3 & -1 \\ 0 & \underline{3} & 3 & -3 \\ 0 & -1 & -1 & 1 \\ 0 & 1 & 1 & -1 \end{bmatrix}$$

$R_3 \rightarrow 3R_3 + R_2$

$R_4 \rightarrow 3R_4 - R_2$

$$\begin{bmatrix} -2 & -1 & -3 & -1 \\ 0 & 3 & 3 & -3 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix}$$

← All Zero Row present below Non Zero Row.

$$\boxed{\rho(A) = 2}$$

Note: (Assumption)

$$\begin{bmatrix} -2 & -1 & -3 & -1 \\ 0 & 3 & 3 & -3 \\ 0 & 0 & 0 & 5 \\ 0 & 0 & 0 & 0 \end{bmatrix}$$

matrix in Echelon form only.

$$\boxed{\rho(A) = 3}$$

Q4) Find the Rank of

$$A = \begin{bmatrix} 2 & 3 & 4 & 5 & 6 \\ 3 & 4 & 5 & 6 & 7 \\ 4 & 5 & 6 & 7 & 8 \\ 5 & 6 & 7 & 8 & 9 \end{bmatrix}$$

Soln:

$$A = \begin{bmatrix} 2 & 3 & 4 & 5 & 6 \\ 3 & 4 & 5 & 6 & 7 \\ 4 & 5 & 6 & 7 & 8 \\ 5 & 6 & 7 & 8 & 9 \end{bmatrix}$$

$R_2 \rightarrow 2R_2 - 3R_1$

$R_3 \rightarrow R_3 - 2R_1$

$R_4 \rightarrow 2R_4 - 5R_1$

$$A = \begin{bmatrix} 2 & 3 & 4 & 5 & 6 \\ 0 & -1 & -2 & -3 & -4 \\ 0 & -1 & -2 & -3 & -4 \\ 0 & -3 & -6 & -9 & -12 \end{bmatrix}$$

$R_3 \rightarrow R_3 - R_2$.

$R_4 \rightarrow R_4 - 3R_2$.

$$A = \begin{bmatrix} 2 & 3 & 4 & 5 & 6 \\ 0 & -1 & -2 & -3 & -4 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

$$\boxed{\rho(A) = 2}$$