MADE EASY

ELECTRICAL ENGINEERING

POWER ELECTRONICS

BY-JAGDEESH SIR

- Theory
- Explanation
- Derivation
- Example
- Shortcuts
- Previous Years Question With Solution

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↑)
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

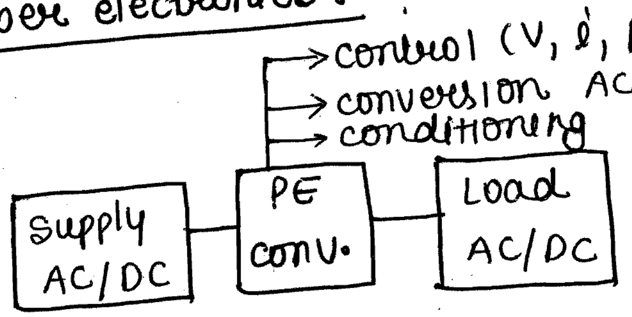
only for ESE

(vi) Resonant converters

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

(viii) SMPS

Power electronics :- ?

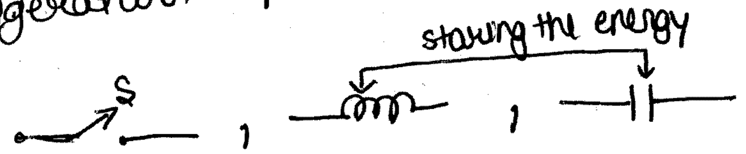


control (V, i, P, f) / AC → AC / DC → DC / DC → AC

conversion AC → DC

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-: stabilizer to Refrigerator. i.e; conditioning of electrical power

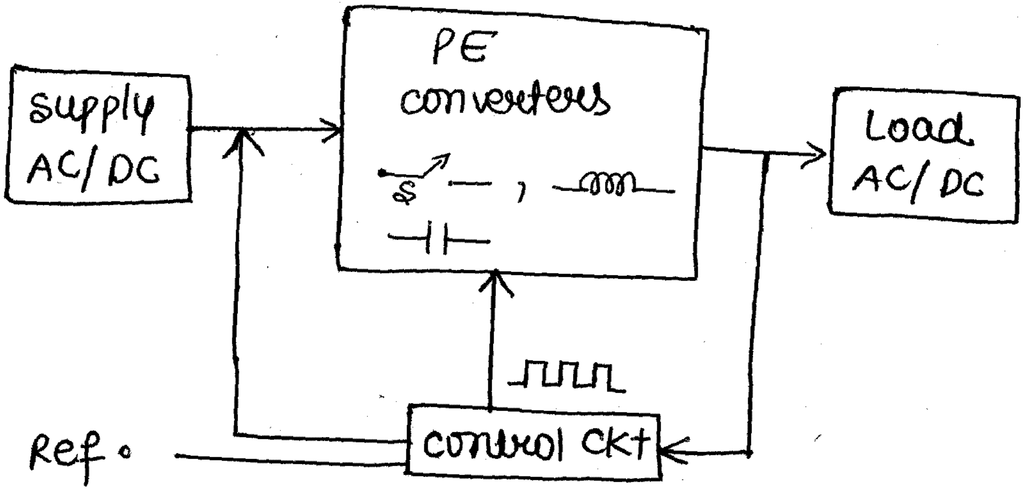


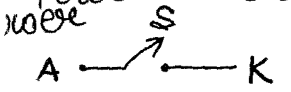
↳ Not used because power dissipation element.

selection of switches depend on
→ power rating
→ voltage rating

freq. rating.

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





Power electronic deals with control, conversion and conditioning of electric power using semiconductor devices & these sc devices should operate with high efficiency. In power electronic, semiconductar 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.

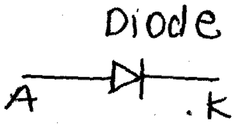
Suppose diode —▷|— is only having two terminal Anode & cathode not having Gate (G) terminal that's why diode is uncontrolled device.

cycloconverter : V_0, f_0 ↗
AC → AC

High power & low speed in drive

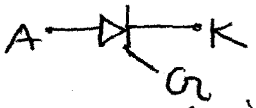
Semiconductar Switches :-

(i) uncontrolled switch : (eg) Diode , DAIC



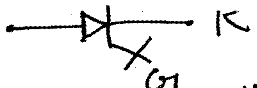
In the diode device there is no gate terminal so the ON/OFF state of diode will not decide then who decide the ON/OFF state of device? Nature of the ckt will decide it.

(ii) semicontrolled switch : (eg) , TRAIC



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

(iii) Fully controlled switches : (eg) GTO

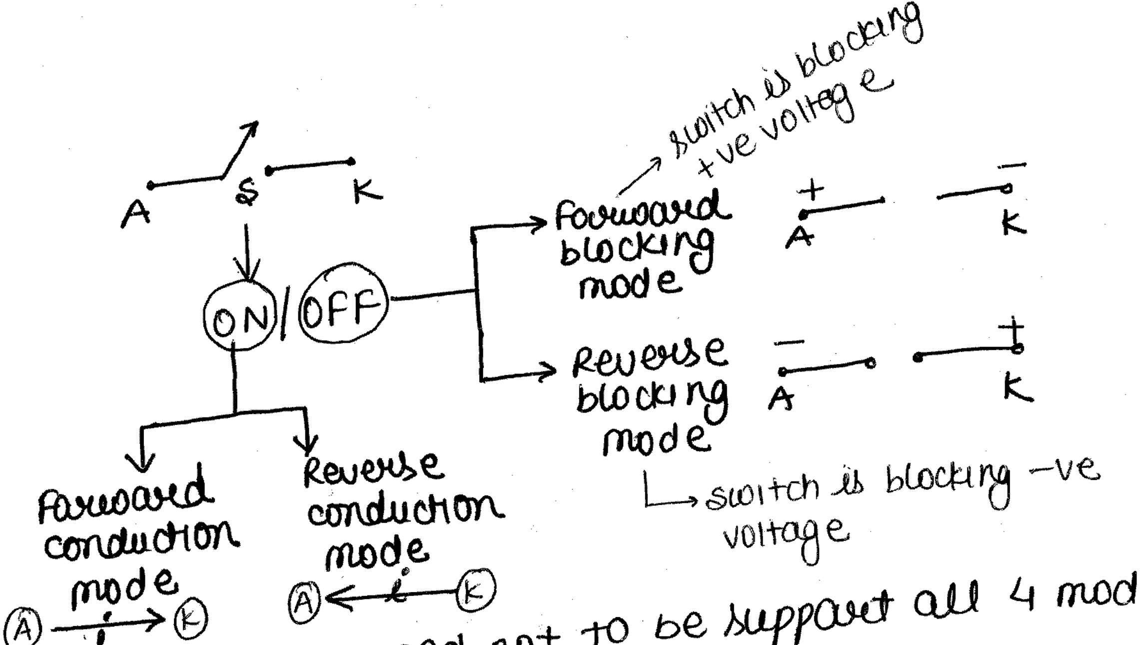


Gate is controlled terminal which decide both ON & OFF state.

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

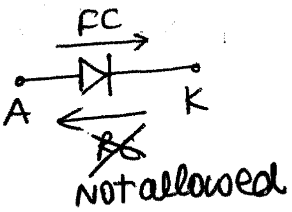
$-I_g$ to Gate terminal then GTO ≡ OFF

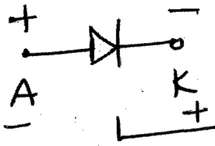
(eg) BJT, MOSFET, IGBT



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

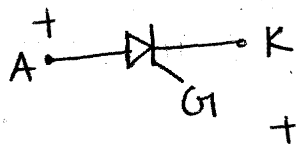
Eg-: Diode





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

it can block Reverse voltage RB ✓



SCR

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

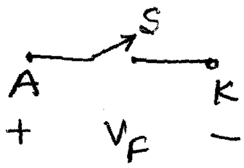
it can block the reverse voltage also when Gate=0 & current direction is only one way.

SCR → FB, RB → bipolar blocking capability

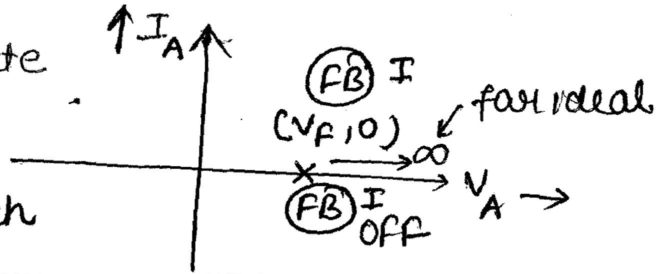
Diode	SCR
FC, RB	FB, RB, FC bipolar capability blocking with unidirectional current

Four-mode of an ideal switch :-

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



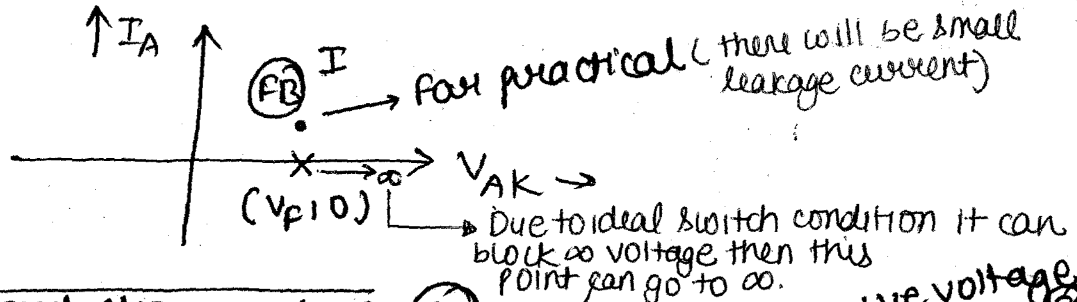
$\underbrace{(V_F, 0)}_{\text{for ideal switch}}$



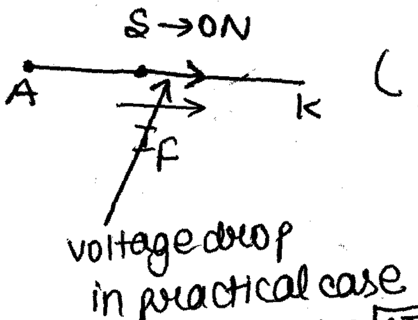
An ideal device when blocking the forward voltage (V_F) then current passing through the device is zero Amp but in practical some leakage current flow through it due to minority current Now, we are having some losses in semiconductor device even in the OFF state i.e, blocking power loss = [$V_F \times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

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

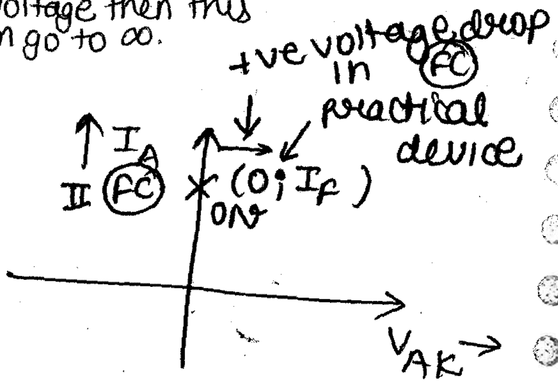
x → ideal
∘ → practical



(ii) Forward conduction mode : (FC)



$\underbrace{(0, I_F)}_{\text{for ideal switch}}$



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

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 ↑

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Power System-1

By.Balaji Sir

- Theory
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Standard voltages used in India :-

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

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

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

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

Houses uses - 230V (phase voltage)

Frequency f = 50Hz

HVDC ± 500 KV, ± 800 KV, f = 0 Hz

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 M

WR : 74320 MW by coal largest

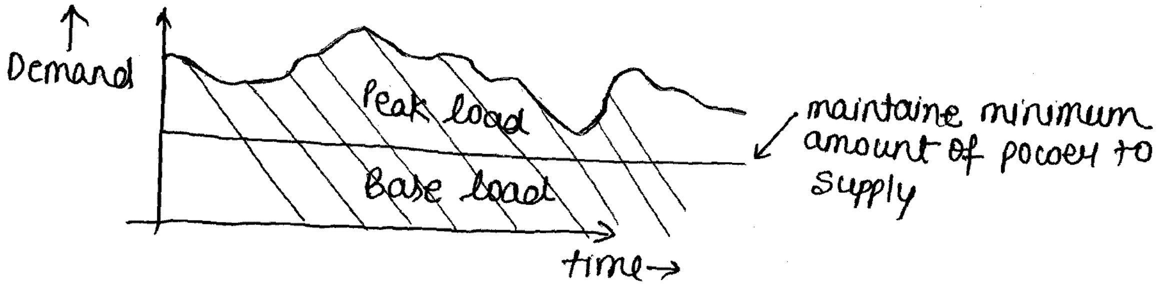
NER : 770 MW by coal smallest

power utilisation

Thermal : Coal + Lignite + Gas + Diesel

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

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

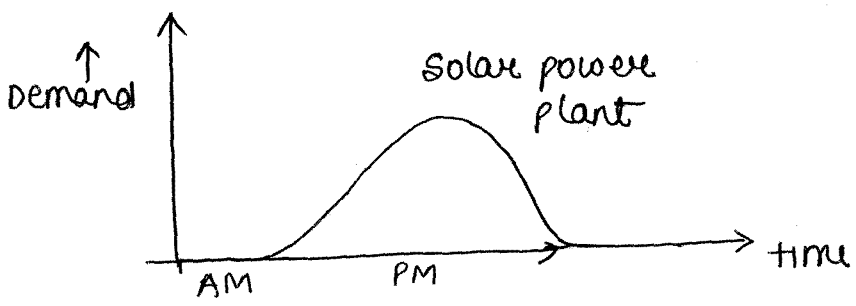


Base load -: Thermal plant Next to peak load : Gas, wind, solar

Peak load -: Hydro plant

1 kwhr = 1 unit

2019-20 1208kwh per capita consumption



objectives of Power system :-

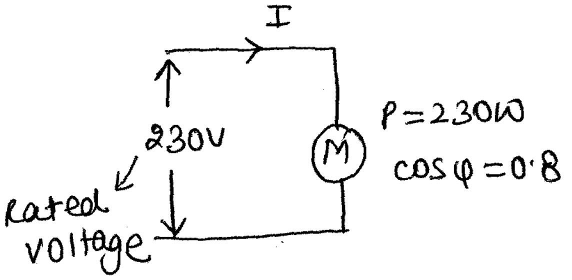
(i) Cost of electric energy must be low.

- 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



$$P = VI\cos\varphi$$

$$I = \frac{P}{V\cos\varphi} = \frac{230}{230\times0.8} = 1.25A$$

suppose supply voltage get reduce to V=200volts then current drawn by motar will be $I = \frac{230}{200\times0.8} = 1.4375A.$

$$\%\text{ increase in current} = \frac{1.4375-1.25}{1.25}\times100 = 15\%$$

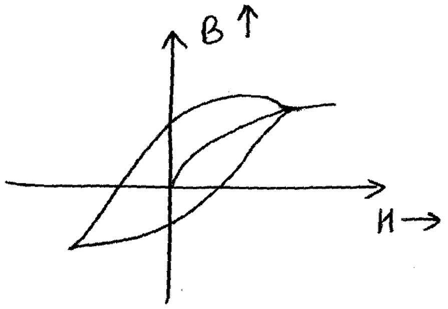
current drawn by motar is high value. this will causes overheating

To get constant voltage — voltage/Reactive power control

(iv) Maintaine Rated frequency

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

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



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

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

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

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

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

x = layer number

d = Dia of each strands

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

Power carrying capacities at 65°C :-

At 132 KV with 'Panther' ACSR = 75 MVA

At 220 KV with 'zebra' ACSR = 200 MVA

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

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

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

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

Tower configuration :-

3 bundle conductor not practically used due to mechanical strength.

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Power System-2
By.Bhoopender Sir

Power System - 2

Book:- Steven son
- Nagrath Kothari

- Standard book solved examples.
- IES mains solved problem.
- W.B. | IES previous year
- Gate previous year

---- Bhupendra Singh sir

Topics:

	For Gate	For ESE
	5 to 8	Mains (MImp)

① Fault

② E.D.

③ Load flow

④ Stability

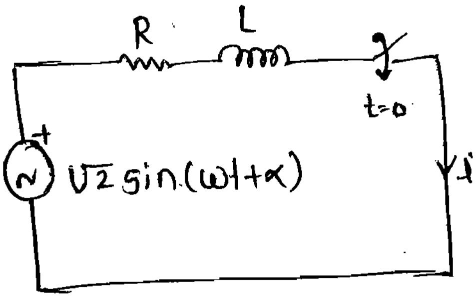
"No Selection, Without Revision"

8|06|2021
Lec-1

Power Analysis of Ac Circuit:

⊙ Ac Circuit:

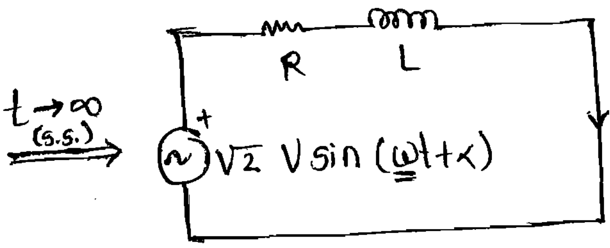
⇒ A circuit which is in steady state corresponding to a given sinusoidal excitation is called Ac circuit.



Sinusoidal exponential

$i(t) = i_{ss} + i_{TR}$.

--- Not an Ac circuit.



Response freq. is same as the Source. freq.

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

--- An Ac Circuit

- Steady state response nature depends upon the Source.
- Transient response nature depends upon circuit itself.
- $i(t) = i_{ss} + i_{TR}$. --- for Non-Ac circuit

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

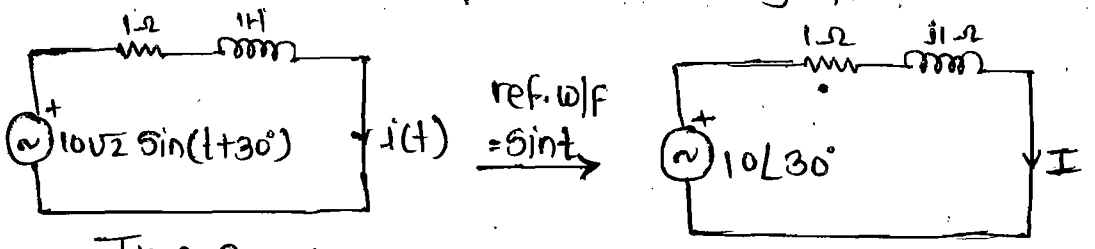
∴ Responses are Non-sinusoidal

- $i(t) = \sqrt{2}\cdot I\cdot\sin(\underline{\omega}t+\beta)$ ---- for Ac circuit.

∴ Response are sinusoidal.

⇒ All the responses of an AC ckt. are sinusoids with freq. equal to the source freq.

⇒ The magnitude (RMS value) and phase of a response in an AC circuit is computed using phasor technique.



Time Domain

Phasor domain equivalent ckt.

- $I = \dfrac{10\angle 30^\circ}{1+j1}$ --- phasor form

$I = \dfrac{10}{\sqrt{2}} \angle -15^\circ$

Time domain	→	R	L	C
Phasor	→	R	$j\omega L$	$\frac{1}{j\omega C}$
Freq.	→	R	SL	$\frac{1}{SC}$

- $i(t) = 10\sin(t-15^\circ)$ --- time domain.

$$v_L(t) = 10\sin(t+75^\circ) \longleftarrow \quad V_L = \frac{10}{\sqrt{2}}\angle 75^\circ$$

$$= \left[\frac{j1}{1+j1}\, 10\angle 30^\circ\right]$$

⊙ Power Calculation:

⇒ Complex power absorbed by AC ckt. | AC ckt. element:- (Fig ⓐ)

$$S = VI^* = P + jQ$$

where,

P = Active Power | Avg. Power | Useful Power Absorbed by AC ckt. | AC ckt. element (Watt)

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

$P>0$: ckt / ckt element absorbed Active power

$P<0$: ckt / ckt. element delivers Active power.

$Q>0$: ckt. / ckt. element absorbed Reactive power. (or)
ckt / ckt. element absorbed lagging VAR (or)
ckt. / ckt. element delivers Leading VAR

$Q<0$: ckt. / ckt. element delivers reactive power (or)
ckt. / ckt. element delivers lagging VAR (or)
ckt. / ckt. element leading VAR (absorbed)

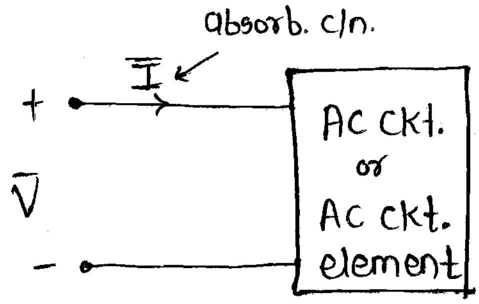


Fig ⓐ

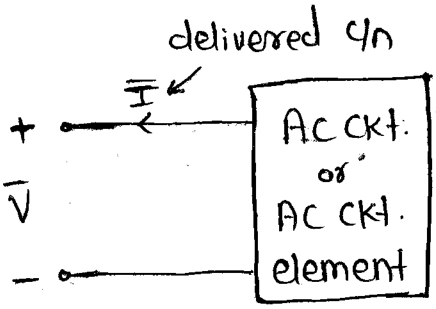


Fig ⓑ

⟹ Complex power delivered by AC ckt. / AC ckt. element :- (Fig ⓑ)

$$S = VI^* = P+jQ$$

where,

P = Active power delivered by AC ckt. / AC ckt. element

Q = Reactive power / laggig VAR delivered by AC ckt. / AC ckt. element.

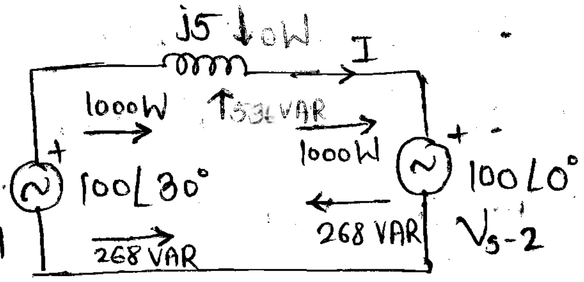
$P > 0$: CKt. delivers active power

$P < 0$: CKt. absorbs Active power.

$Q > 0$: CKt. delivers reactive power.
CKt. delivers lagging VAR | absorbed lead. VAR.

$Q < 0$: CKt. absorbed reactive power.
CKt. ~~deliver~~ absorbed lagging VAR | delivered lead VAR.

Que:



- Pure L & C absorbs 0W in AC condition.
- L absorbs Reactive Power
- C delivers Reactive Power

Soln: • $I = \dfrac{100\angle 30° - 100\angle 0°}{j5}$

$I = 10.35\angle 15°$

- Complex power absorbed by $V_s - 2$

$S = VI^*$

$= (100\angle 0°).(10.35\angle 15°)^*$

$= (100\angle 0°).(10.35\angle -15°)$

$S = 1000 - j268$

∴ Vtg. source absorbs 10000W & delivers 268 VAR.

- Complex Power delivered by V_{s-1}

$$S = VI^*$$

$$= (100\angle 30^\circ)\,(10.35\angle 15)^*$$

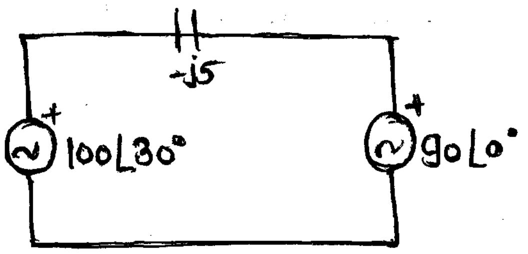
$$S = 1000 + j268$$

∴ Vtg. source -1 delivers 1000W & delivers 268 VAR.

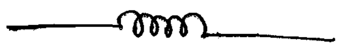
⊛ Note :

In power system, Active Power always flows from leading vtg. source towards lagging vtg. source, whereas, reactive power generally flows from high vtg. magnitude towards low vtg. magnitude.

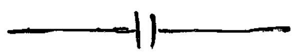
⟹



In power s/m. ckt. in series branch always inductor & in parallel branch alway capacitor.



Lead → Lag

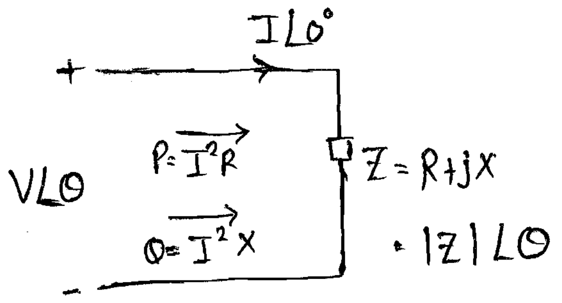


lead ← lag

$Z = R+jX$ = X +ve = L
X −ve = C

$Y = G+jB$ = B +ve = C
B −ve = L

⊙



$$\boxed{\begin{array}{l}|Z| = \sqrt{R^2+X^2}\\ \theta = \tan^{-1}(X/R)\end{array}}$$

⊙ Complex power abs. by $Z = R+jX$

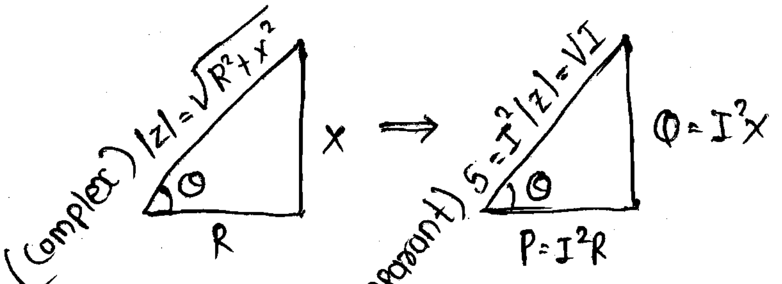
$$S = (V\angle\theta)(I\angle 0°)^* = P+jQ = VI\angle\theta$$

(Active) $P = VI\cos\theta = VI\dfrac{R}{|Z|} = I^2R$ --- (Real part of complex power)

(Reactive) $Q = VI\sin\theta = VI\cdot\dfrac{X}{|Z|} = I^2X$ --- (Img. part of complex power)

⊙ Apparant power:

$S = I^2|Z| = VI$ ... (magnitude of complex power)



--- power triangle

⊙ power factor: $\cos\theta = \dfrac{P}{S} = \dfrac{\text{Active Power}}{\text{Apparant Power}}$ --- P.S.

$\cos\theta = \cos\tan^{-1}\left(\dfrac{Q}{P}\right)$ --- m/c

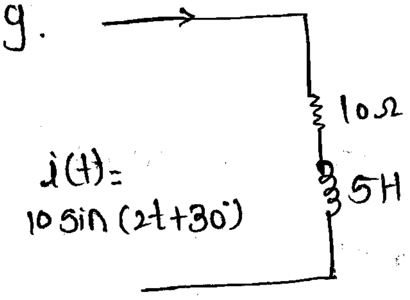
θ = angle betn vtg. phasor & c/n phasor

- Resistance: It is the real part of impedance.
- Reactance: It is the imaginary part of impedance.

$R \geq 0 \longrightarrow P \geq 0 \implies Z = R + jX$: cant delivered Active power

$X > 0$ (Inductive Impedance)	$X = 0$ (Resistive Impedance)	$X < 0$ (Capacitive Impedance)
- Inductive impedance absorbed Rea. power - Inductive impedance absorbed Lag. VAR - Inductive impedance del. lead. VAR.	- $\Phi = 0$	- capacitive impedance del. Reactive power - capacitive impedance del. Lag. VAR - capacitive impedance absorbed lead. VAR.

e.g.

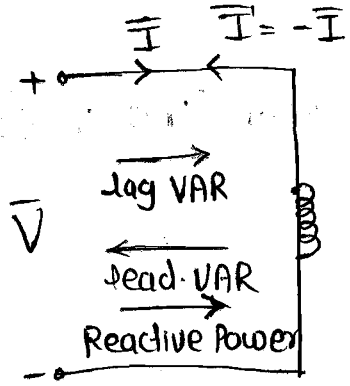


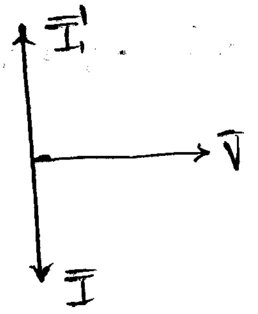
Sol^n:

$P = I^2R = \left(\frac{10}{\sqrt{2}}\right)^2 \cdot 10$ Watt

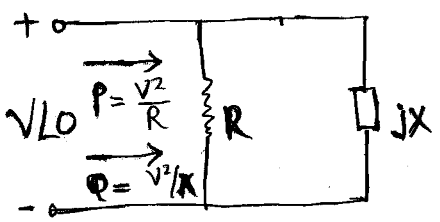
$\Phi = I^2X = \left(\frac{10}{\sqrt{2}}\right)^2 \cdot (2\times5)$ VAR

$\implies$





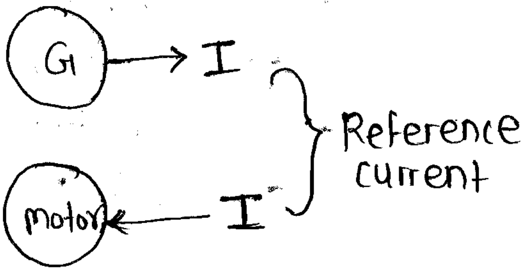
$\implies$



- Significance of Reactive Power:

-

-



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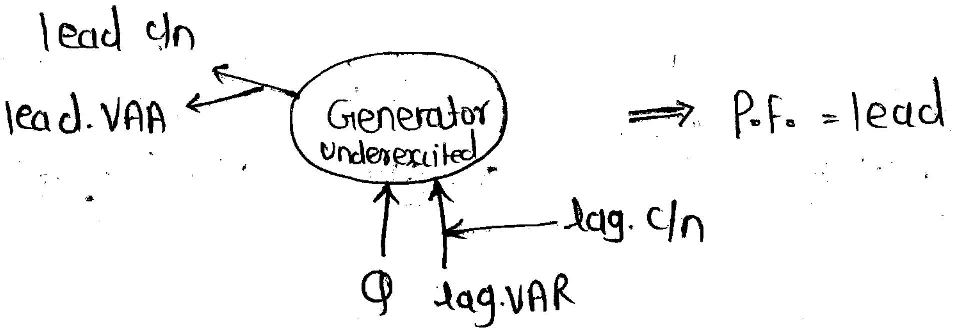


- Flux requirement depends upon operating voltage.

9/06/2021
Lec-2

Balance 3-ϕ System | Concept of phase Sequence

⇒ A polyphase system is said to be balance if

① The magn. of corresponding quantities are equal in each phase.

② The phase difference betn the corresponding quantitive is given by.

$$\Theta = \frac{360^\circ}{n} \; ; \; n \neq 2$$

$$= 90 \; ; \; n = 2$$

$$= \frac{360}{3} \; ; \; n = 3 \quad \text{--- for 3-}\phi \text{ s/m}$$

Que. Current in two phases of two phase s/m is given below. $i_a = \sqrt{2}\, I . \cos(\omega t - \phi_1)$

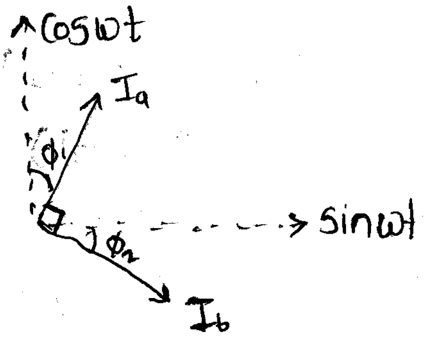
$i_b = \sqrt{2}\, I . \sin(\omega t - \phi_2)$.

Find the relationship betn ϕ_1 & ϕ_2, so that the s/m is balance.

Soln.: leading → +ve ⇒ Anti clockwise

lagging → -ve ⇒ Clockwise

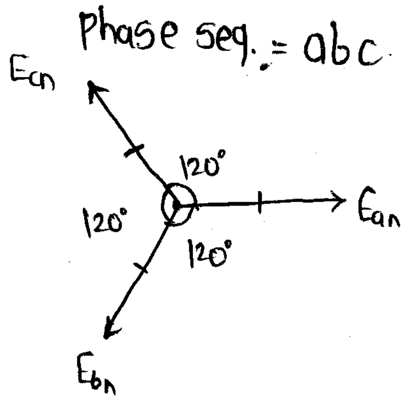
cosωt leads sinωt by 90°.

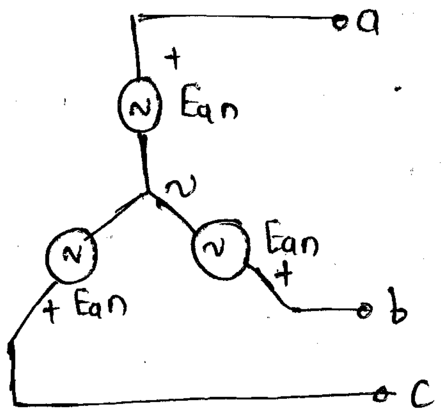


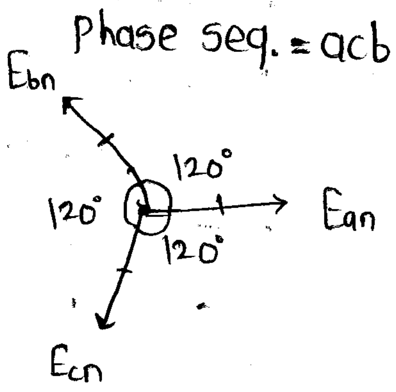
$$\boxed{\therefore \phi_1 = \phi_2}$$

⊙ For 3-ϕ System:

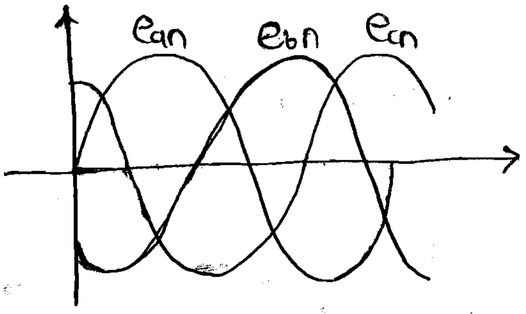
Consider, a balance 3-ϕ (Ideal) Voltage Source. :
↓ No impedance

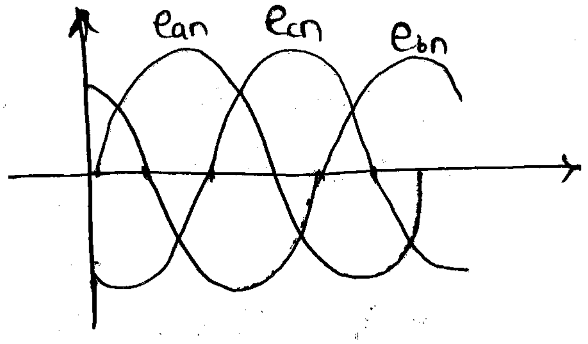






⟹ Both phasor dia. is represent balance condition but they do filler phase sequence.



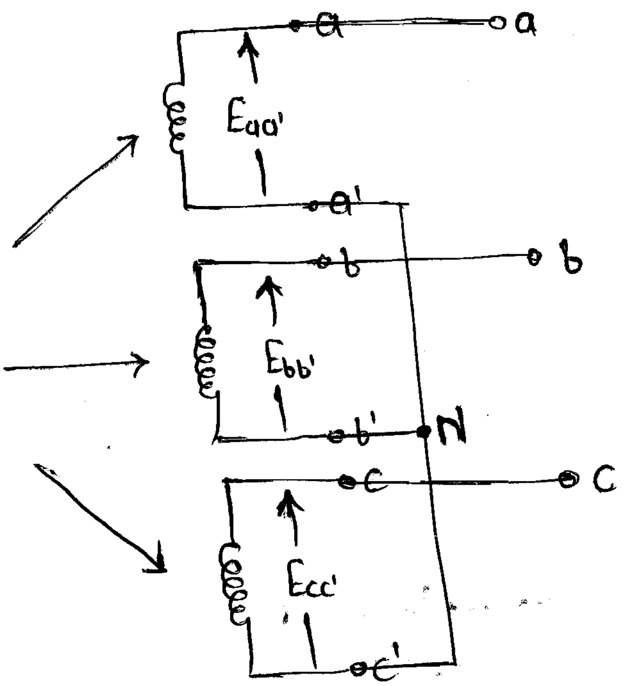


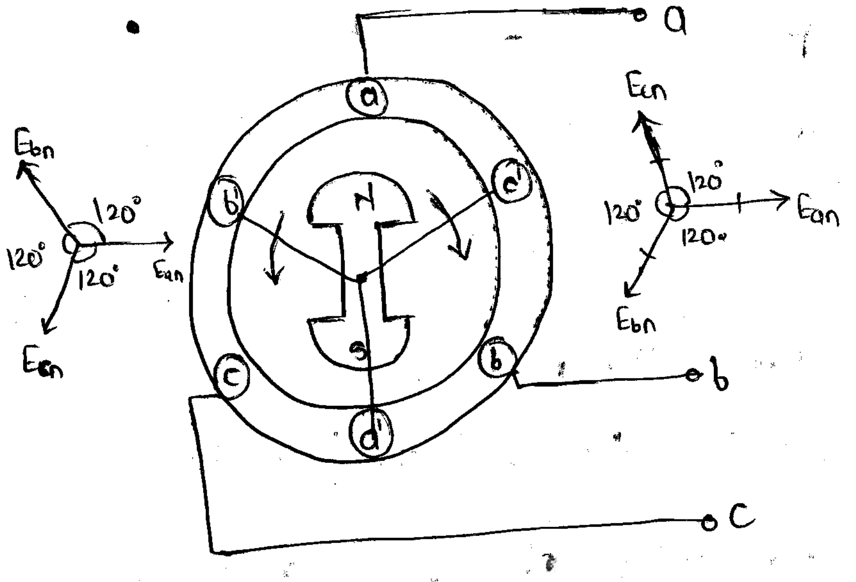
⊙ Phase sequence :

Phase sequence is defined as the order in which the phases attained their maximum value.

⟹ 3-ϕ (Ideal) Voltage Source is ckt. equivalent of a (Ideal) synchronous machiehe.

- Identical winding in all three phases to produce equivalent magnitude of a voltage in all 3-φ's.



- 

$$\boxed{\phi_e = \frac{P}{2}\phi_m}$$

- **Note:**

① only two type of phase sequence (abc & acb) is possible in a 3-φ system.

② The phase sequence can be reverse by reversing the rotation of rotor, but practically doing it is not possible.

③ phase sequence cannot be reverse by reversing the field excitation.

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Transformer Machine
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) Transfer^{mer} operate on the principle of mutual induction. b/w two or more magnetically coupled coils.

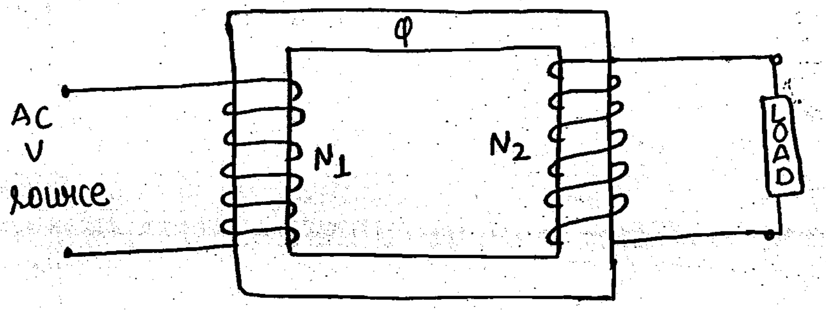
Key word :- Mutual induction principle b/w two or more magnetically coupled circuits (coil / winding)

(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 $\rightleftharpoons$ Mechanical

(iii) It is $\boxed{\text{singly Excited device}}$ i.e; we applied voltage to only one winding of a transformer.

(iv) $\boxed{\text{constant flux device}}$ neglecting the transient charge in flux.

(v) $\boxed{\text{constant power}}$

(vi) $\boxed{\text{constant frequency}}$

(vii) $\boxed{\text{Magnetically coupled circuits}}$[-ve magnetic coupling in accordance to lenz's law]

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

(ix) It is $\boxed{\text{Phase shifting Device}}$ [w.r.t. voltage]

(x) It $\boxed{\text{works only on AC}}$

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-φ T/F

ⓑ 3-φ T/F

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

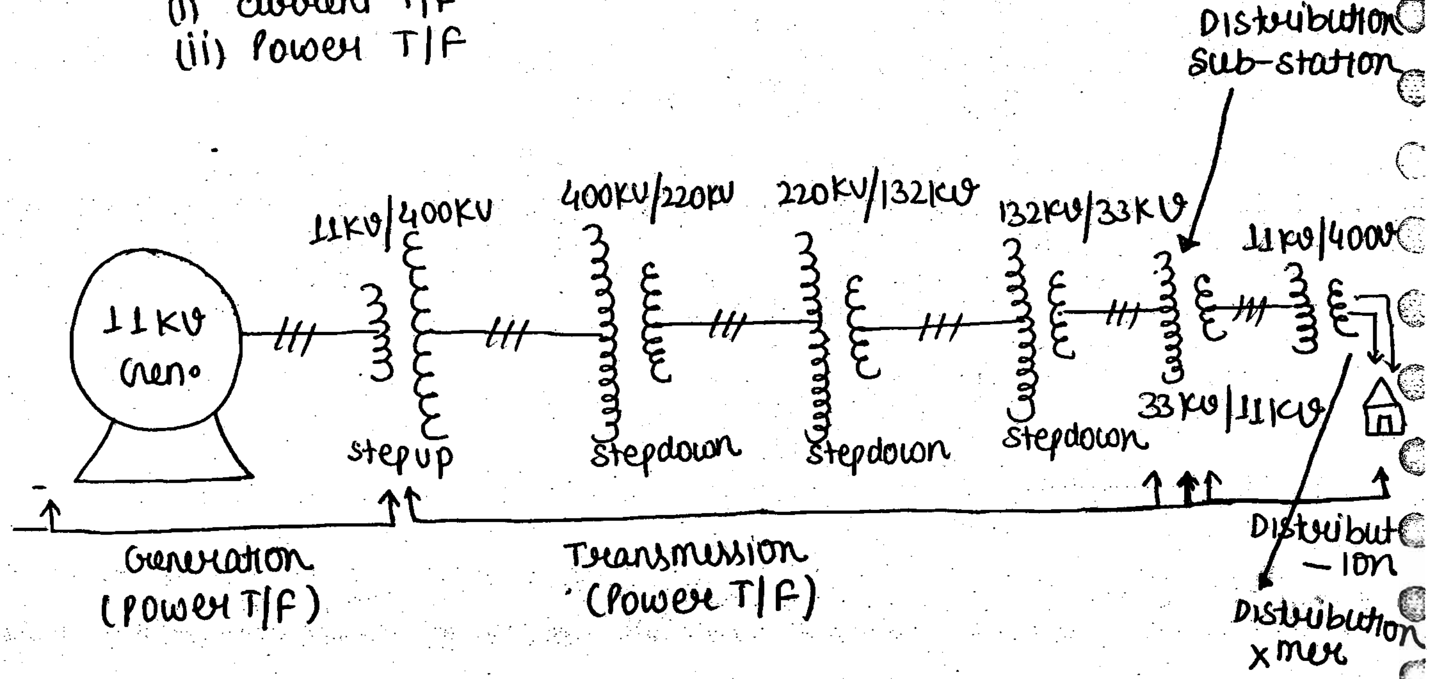
(ii) Gate pulse triggering

ⓒ Instrumentation

(i) current T/F

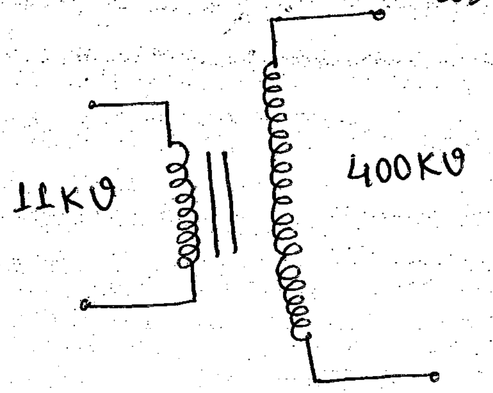
(ii) Power T/F

ⓓ Electronic & control system



NOTE-:

$$\text{Step up} \underset{\text{can be used as}}{\rightleftarrows} \text{Step down T/F}$$



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

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

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-: 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)

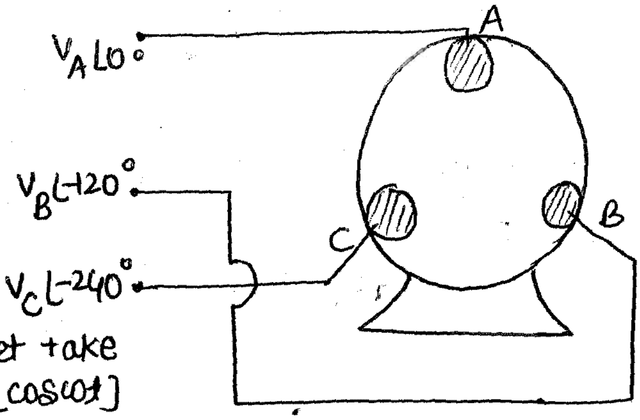
(i) Induction Generator
(ii) Induction motor

Rotating Magnetic field (RMF) :-

In I/M, the flux is not stationary, it is rotating.
The basic requirement to produce the rotating magnetic field is

(i) 3φ supply ($120°E$ phase displacement w.r.t. time)
(ii) 3φ winding ($120°E$ phase displacement w.r.t. space)
} Balance

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



let take
[$\cos\omega t$]

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

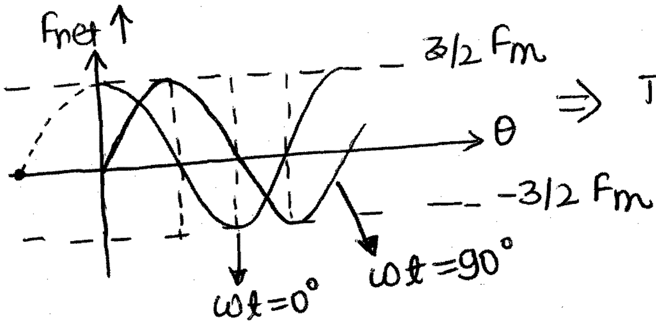
$$\boxed{f = \frac{PN}{120}}$$

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.

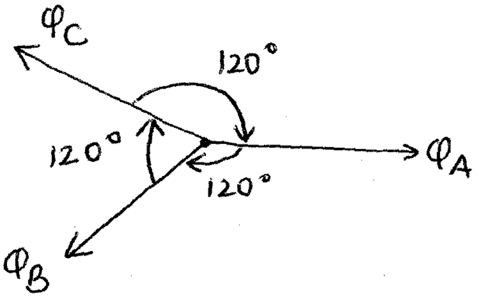
NOTE:- By reversing the phase sequence the direction of movement of mmf is also reverse.

Another approach:-

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

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

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

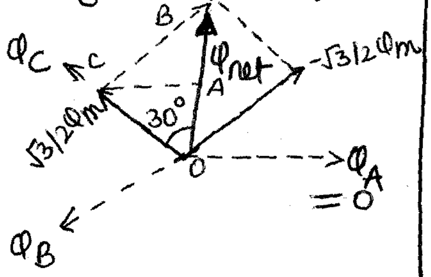


At $\omega t = 0°$

$\varphi_A = 0$

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

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



$OB = 2OA$, $\angle AOC = 30°$

From ΔOAC

$\cos 30° = \frac{OA}{OC}$

$OA = OC\cos 30°$

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

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

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

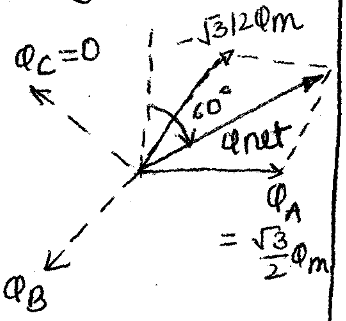
$$\boxed{\varphi_{net} = \frac{3}{2}\varphi_m}$$

At $\omega t = 60°$

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

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

$\varphi_C = 0$



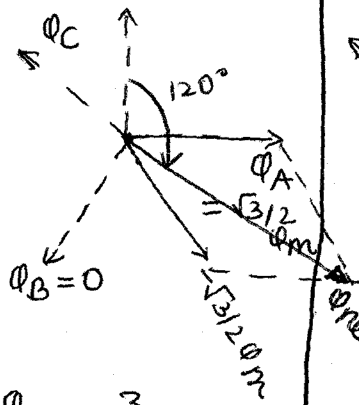
$\varphi_{net} = \frac{3}{2}\varphi_m$

At $\omega t = 120°$

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

$\varphi_B = 0$

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



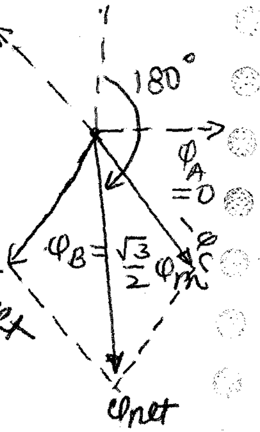
$\varphi_{net} = \frac{3}{2}\varphi_m$

At $\omega t = 180°$

$\varphi_A = 0$

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

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



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

synchronous

⇓

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.

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

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SYNCHRONOUS MACHINE

By-MURLI Sir

- Theory
- Explanation
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- Example
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SYNCHRONOUS MACHINES

Gen M-E Motor E-M Condenser ↑p.f

Gen M → E Motor E-M condenser ↑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 ∴
  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

$$I = \frac{500\times10^6}{\sqrt{3}\times11\times10^3} = 26243\ A$$

* 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 slots will offer better insulation as well as they offer more space.

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

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

5) **Rigid 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.

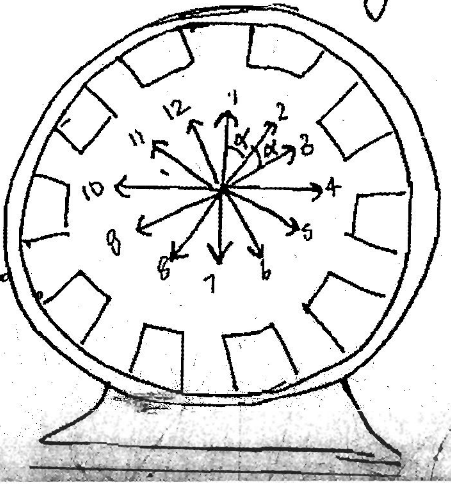
6) <u>Leakage Reactance</u>:- will be less because stator offers more width in the slots and contains more cu per slot. If it is on rotor depth will be high due to less space which produces more leakage reactance

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 MACHINE

Lecture 01

→ Transformer] static m/c

→ Dc Machine]
→ Induction machine] Rotating M/C
→ Synchronous machine]

** special machine

Basic Concepts of Rotating machine

Rotating m/c are of two types

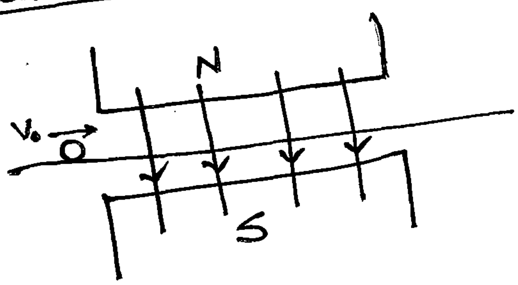
(1) Generator [mech energy → Electrical Energy] in presence of mag. field

(2) Motor [Electrical energy → Mechanical Energy]

Magnetic field acts as a coupler b/w mechanical energy and electrical energy means it provides a medium from one form to another.

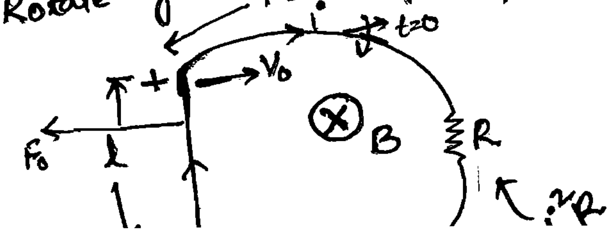
Assumption:
Lossless system

Basic Generator



Rotate by 90°

Polarity by Right hand palm rule



$e = (\vec{v} \times \vec{B}) l$

$|e| = v B l \sin\theta$

$E_0 = V_0 B l \quad \because \theta = 90^\circ$

At $t = 0^+$

$I_0 = \frac{E_0}{R} = \frac{V_0 B l}{R}$

As this current carrying conductor is placed in a magnetic field a force is developed in a conductor and is given by

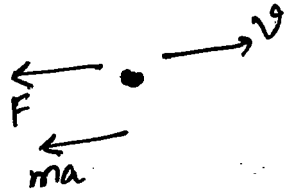
$F = \vec{i} l \times \vec{B}$

$F_0 = \vec{I_0} l \times \vec{B}$

$|F_0| = I_0 l B \sin\theta'$

$F_0 = I_0 l B \quad \because \theta = 90^\circ$ (using Right hand Palm rule)

Free body Diagram (FBD) of Conductor



$ma + f = 0$

$m\frac{dv}{dt} + ilB = 0$

$\frac{dv}{dt} = -\frac{ilB}{m} \rightarrow ①$ $\quad i = \frac{e}{R} = \frac{vBl}{R} \rightarrow ②$

From (1) & (2)

vB^2l^2

$$\frac{dv}{v} = \frac{-B^2l^2}{mR}dt$$

On integrating

$$\ln v = -\frac{B^2l^2}{mR}t + K_1$$

$$v = e^{-\frac{B^2l^2}{mR}t} + K_1$$

$$v = K_2 e^{-\frac{B^2l^2}{mR}t}$$

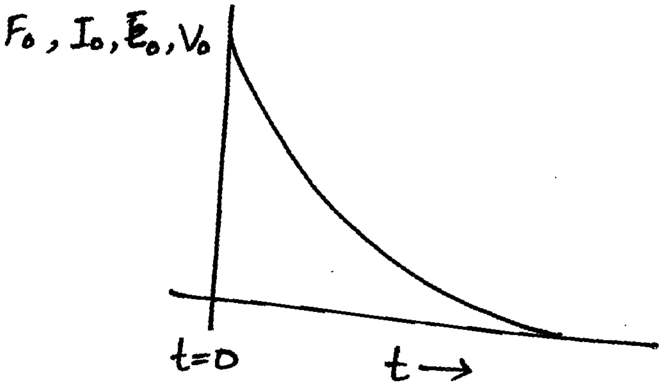
At $t=0$ $v = V_0$

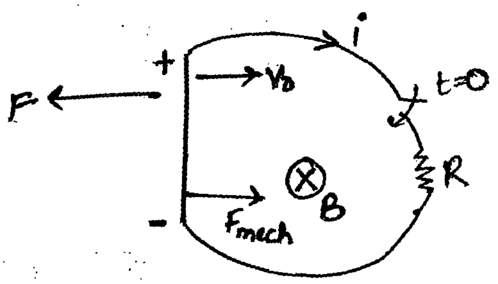
$$\boxed{v = V_0 e^{-\frac{B^2l^2}{mR}t}} \longrightarrow (A)$$

$$\boxed{e = vBl = V_0 Bl e^{-\frac{B^2l^2}{mR}t}} \longrightarrow (B)$$

$$\boxed{i = \frac{e}{R} = \frac{V_0 Bl}{R} e^{-\frac{B^2l^2}{mR}t}} \longrightarrow (C)$$

$$\boxed{F = ilB = \frac{V_0 B^2l^2}{R} e^{-\frac{B^2l^2}{mR}t}} \longrightarrow (D)$$





Ir | |F|

Generator Principle:

An electric generator is based on the principle that whenever a flux is cut by a conductor an emf is induced which will cause a current to flow if the conductor ckt is closed. The direction of induced emf (hence current) is given by Fleming's Right hand rule.

Therefore the essential components of a Gen are

(i) mag. field

(ii) conductor or group of conductors

(iii) motion of conductor wrt mag. field

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ELECTRICAL ENGINEERING

Network Theory

By.Aditya Sir

NETWORK THEORY

-Aditya sir

ESE : 22-24 M
≈ 14 que.
Gate : 10 M

◉ 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

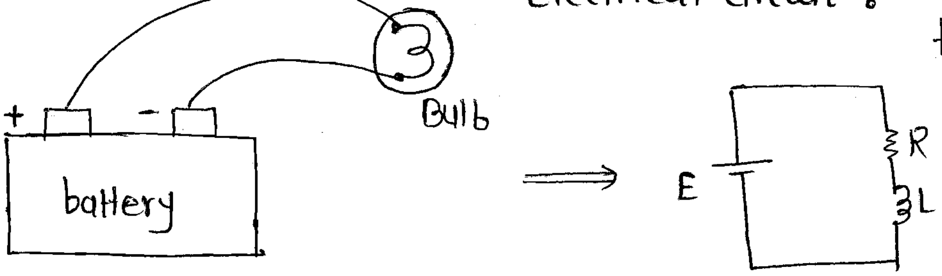
③ Theorems :
- superposition
- Thevenin
- Nortons
- Maximum power Transfer
- Reciprocity
- Millman's
- compensation
- substitution
- Tellegen's theorem

Gate (superposition, Thevenin, Nortons, Maximum power Transfer)

ESE (superposition … Tellegen's theorem)

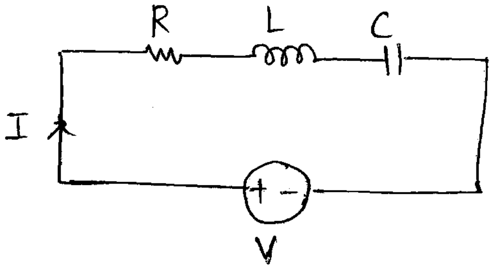
④ Transient :
- 1st order circuit (RC, RL)
- 2nd order circuits
- Initial condition
- Laplace transform

⊙



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

⊙



Interview

Highest basic quantity in electrical Network : Charge

① Charge :- charge is the electrical property of the atomic partical of which the Matter consist of. (C)

• [Electrical Property → Atomic Particles → Matter]

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

Coulomb is the large unit of charge.

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

Soln:
$1e^- = 1.6 \times 10^{-19} C$

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

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

⊙ Law of Conservation of charge:

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

Any eqn with the help of show Low 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)

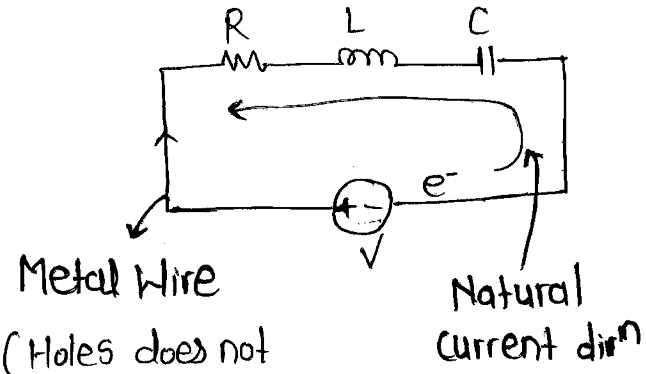
$$\boxed{I_{av} = \frac{\Delta q}{\Delta t}} \quad C/s \text{ or AMP.}$$

- 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:



(Holes does not exist in a metal)

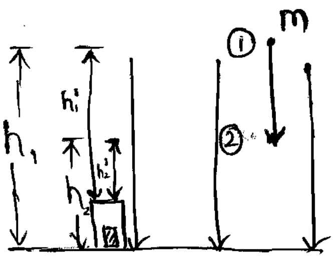
Conventionally, ---> the current direction is taken in the direction of the positive charge moment.

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

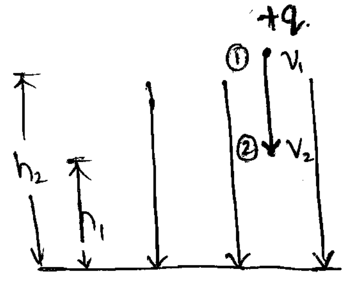
$$\boxed{E = V = \frac{dW}{dq}} \quad J/C \text{ or } V$$

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



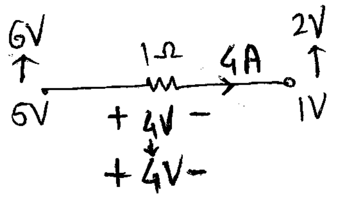
Energy gained by the mass in moving from pt. ① to ② :

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

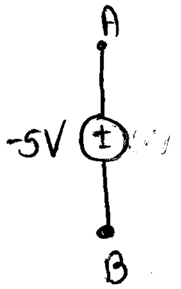


Energy gained by the charge in moving from pt ① to ② :

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



Que:



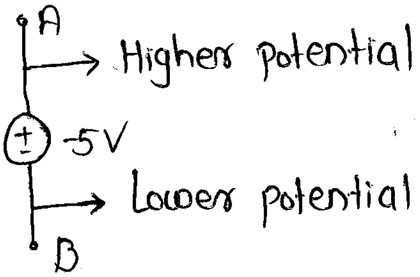
ⓐ $V_A > V_B$

ⓑ $A_A = V_B$

ⓒ $V_A < V_B$

ⓓ Cant Comment

Sol^n:



$$\underset{\text{Pot.}}{\text{Higher}} - \underset{\text{Pot.}}{\text{Lower}} = -5V$$

$$V_A - V_B = -5V$$

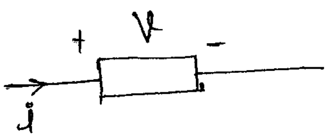
$$V_A = V_B - 5$$

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

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

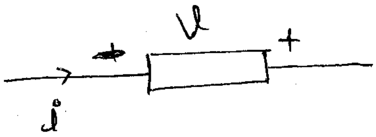
$$P = \frac{dW}{dq} \cdot \frac{dq}{dt}$$

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



$P = +vi$

ⓐ



$P = -vi$

ⓑ

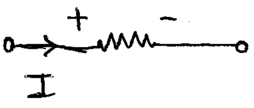
- Whenever we calculate the power by using the formula V×I, We always get the power absorbed.

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

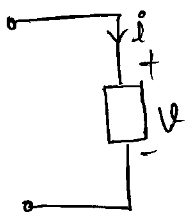
② And when the current leaves from the +ve terminal or current enter into the -ve terminal, then the element delivers the power.



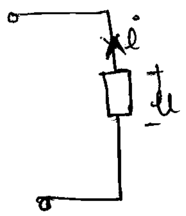
Power absorbed

Power delivered

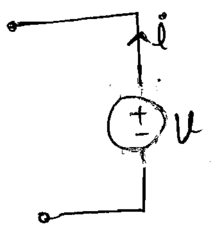
- Hence, for determine sign of the power, The voltage polarity & the c/n direction are important.



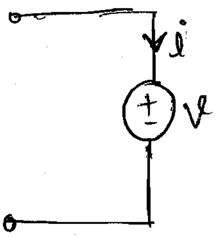
Power abso.
∴ Load



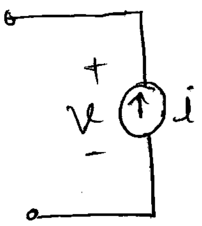
Power deli.
∴ Source



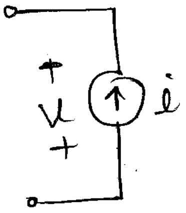
Power deli.
∴ Source



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 :

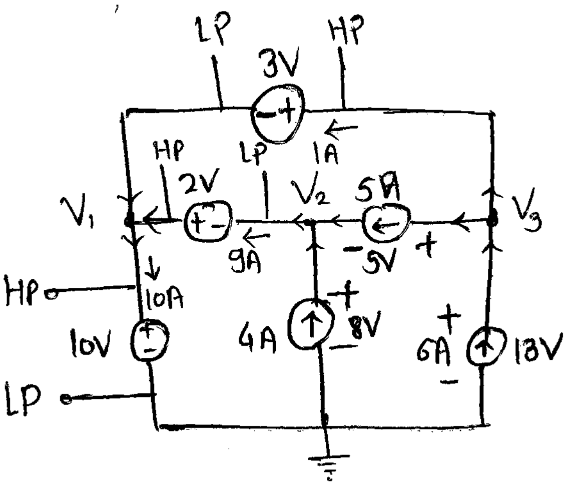
$\Sigma P = 0$

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

- 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 eleement In the below given electrical Network.



Soln:

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

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

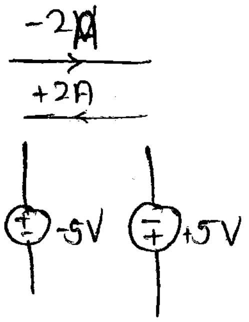
$$P_{3V} = +3 \times 1$$
$$= 3W$$

- 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:

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

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

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

Que: How many elections 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^-

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

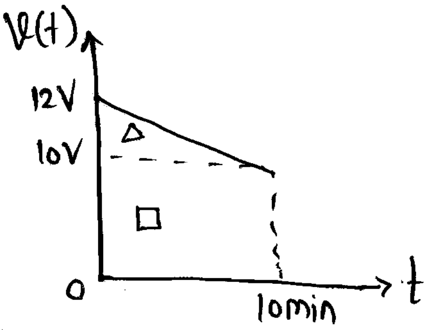
⑤ **Energy** : It is the capacity or ability to do the work. (J or Watt-sec)

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

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

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

Gate 2009



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

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

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

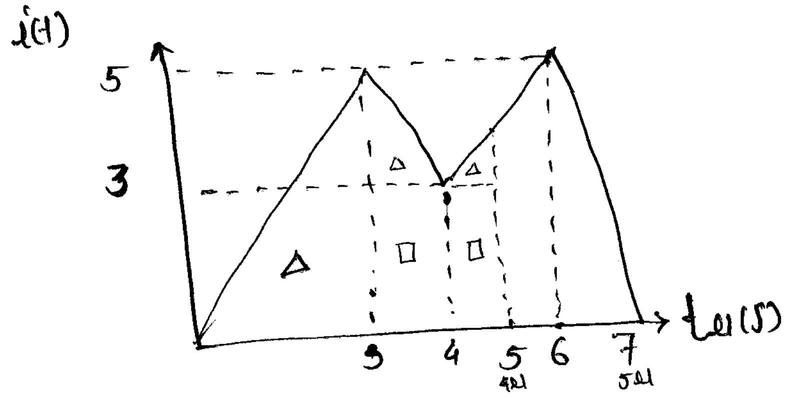
$= 2\left[\left(\frac{1}{2} \times 10min \times (12-10)\right) + (10 \times 10)\right].60$

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

$= 2 \times 6600$

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

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



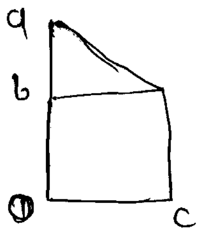
Solⁿ: $i(t) = \frac{dq}{dt}$

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

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

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

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



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

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

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

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

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

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

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

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

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

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

Soln: Given;

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

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

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

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

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

$$= 36 + 15$$

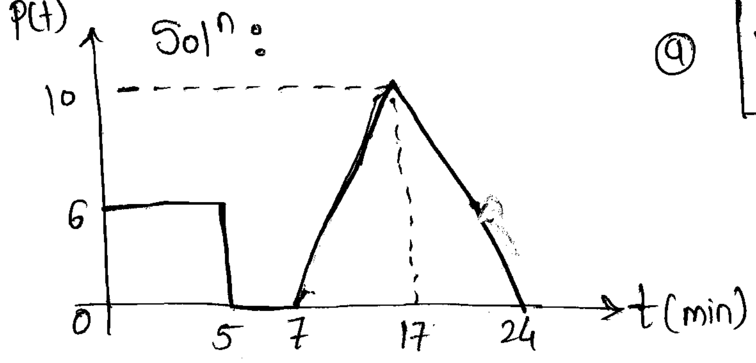
$$\boxed{q(t) = 51C}$$

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

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

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

Soln:



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

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

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

$$= (115\times60)$$

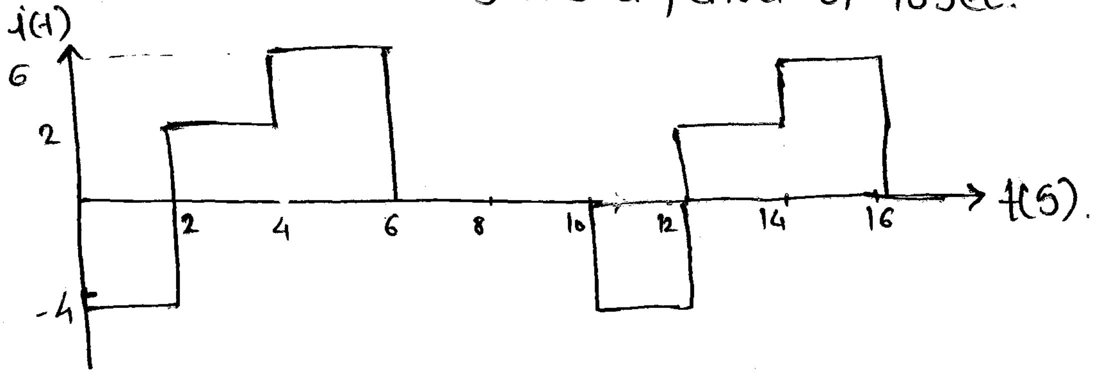
$$W = 6900\,J$$

ⓑ $\boxed{P_{av} = \frac{1}{T}\int_0^T p(t)\cdot d(t)}$

$\frac{W}{T} = \frac{115 \times 60}{24 \times 60}$

$P_{av} = \frac{115}{24} = 4.79\ W$

Que: The Waveform shows has a period of 10sec.



ⓐ What is the avg value of c/n over one period.

ⓑ How much charge is transfered in time interval 0 to 12 sec.

ⓒ If the initial charge is '0' then sketch q(t) for time interval 0 to 16 sec.

Solⁿ: $\boxed{I_{avg.} = \frac{1}{T}\int_0^T i(t).dt}$

$= \frac{1}{10}\{[-4\times2]+[2\times2]+[2\times6]\}$

$= \frac{1}{10} \times [-8+4+12]$

$= \frac{16-8}{10}$

$= \frac{8}{10}$

$I_{avg.} = 0.8\ A$

ⓑ $q(t) = q(0) + \int_0^t i(t)\cdot dt.$

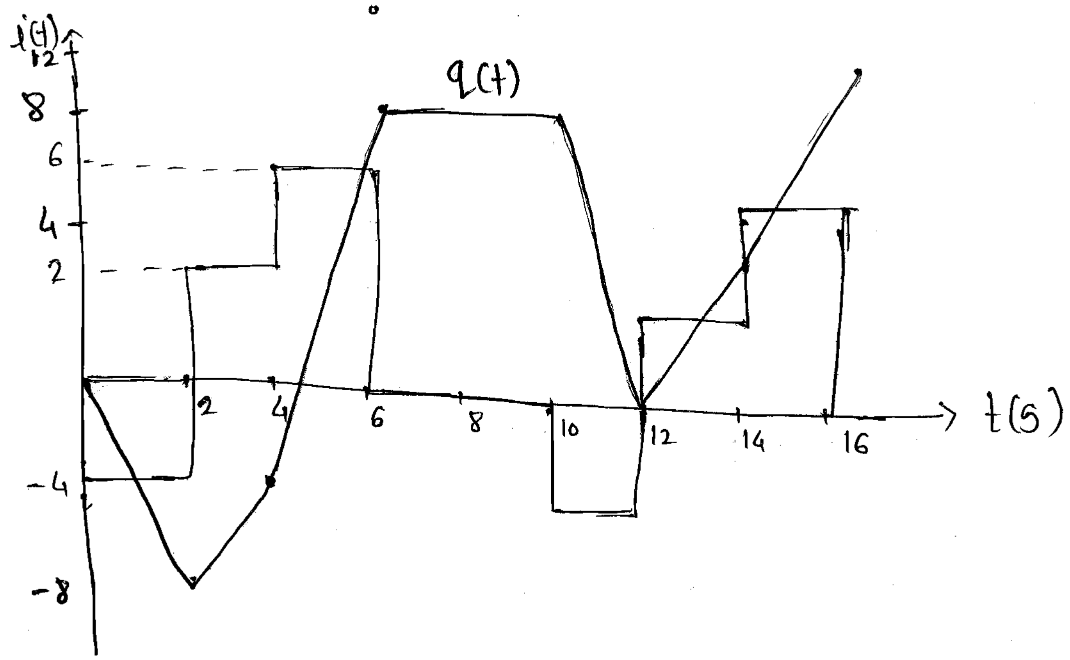
$= 0 + [-8 + 4 + 12 - 8]$

$q(t) = 0C$

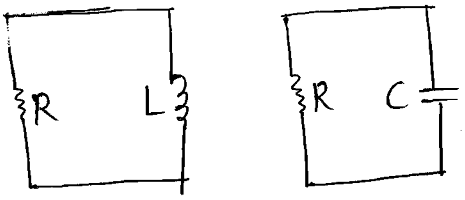
ⓒ step $\xrightarrow{\int}$ ramp

$\int \underset{\uparrow}{a} \cdot dt = \overset{\text{slope}}{at}$

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



Lec-4



Interview:

In given ckts.

RL, Why T.C. (τ) $\propto \frac{1}{R}$

RC, Why T.C. (τ) $\propto$ R

$\tau = \frac{L}{R}$ $\tau = RC$

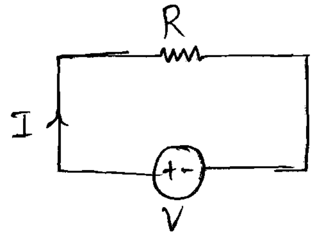
Circuit Elements:

ckt elements can be completely characterised based on its V-I. characteristics:

① **Resistor:** - If voltage across an element is linearly proportional to the current flowing through it, then that element is called as Resistor.

- Resistor is an element having a property of resistance.

Resistance can be described as that property of circuit element which offers, the opposition to flow of the current & in doing so it converts the electrical energy into heat energy.



$P = V.I$

$P = (IR)I. = V. \frac{V}{R}$

$P = I^2R = \frac{V^2}{R}$

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

$= \int_0^t I^2R.dt = \int_0^t \frac{V^2}{R}.dt$

$$\boxed{W = I^2R.t. = \frac{V^2}{R}.t}$$

$$\boxed{R = \frac{W}{I^2t}} \qquad \boxed{W = \int_0^t (I^2)R.dt}$$

MADE EASY

ELECTRICAL ENGINEERING

E.M.T

By-Himadri Shekhar Sir

- Theory
- Explanation
- Derivation
- Example
- Shortcuts
- Previous Years Question With Solution

EMT

- Syllabus (GATE/ESE)

i) Vector Analysis

- Co-ordinate system
- vector calculus

ii) Electrostats

iii) Magneto-stats

iv) Time Varying field [Maxwell Eq^ns]

- Average weightage

  Gate : ~ 4Marks

  ESE : 30 Marks

- Reference Book (optional)

  Sadiku

- Question Practice

  Gate PYQ [10-15 Y]

  ESE PYQ [10-15 Y]

- Test Series

CHAPTER-01 : VECTOR ANALYSIS

01. Co-ordinate System:

There are 3 types of Coordinate systems

i) Cartesian Co-ordinate System $\{x, y, z\}$

ii) Cylindrical co-ordinate system $\{\rho, \phi, z\}$

iii) Spherical Co-ordinate System $\{r, \theta, \phi\}$

These 3-Coordinate system obeys following rules

i) Orthogonality:

a) The dot product of two similar unit vectors of same Co-ordinate system results to 1.

$\hat{a_x} \cdot \hat{a_x} = 1$; Ca. Co. sys

$\hat{a_\rho} \cdot \hat{a_\rho} = 1$; Cy. Co. Sys

$\hat{a_r} \cdot \hat{a_r} = 1$; Sp. Co. Sys

b) The dot product of two different unit vectors of Same coordinate system results to 0.

$\hat{a}_x \cdot \hat{a}_y = 0 \quad \left\{ |\hat{a_x}|\,|\hat{a_y}| \cos \angle_{\hat{a_y}}^{\hat{a_x}} \right. = 1 * 1 * \cos 90 = 0$

$\hat{a_\rho} \cdot \hat{a_\phi} = 0$

$\hat{a_r} \cdot \hat{a_\theta} = 0$

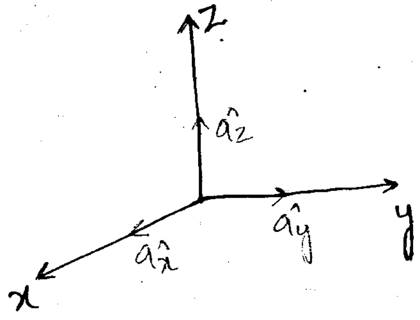
02. Orthonormality:

a) The cross product of two similar unit vectors of same co-ordinate system results to 0.

- $\hat{a_x} \times \hat{a_x} = 0$
- $\hat{a_\rho} \times \hat{a_\rho} = 0$
- $\hat{a_r} \times \hat{a_r} = 0$

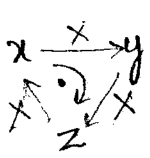
b) The cross product of two different unit vectors of the same co-ordinate system results to third unit vector which is mutually perpendicular to the initial vectors.

- $\hat{a_x} \times \hat{a_y} = \hat{a_z}$



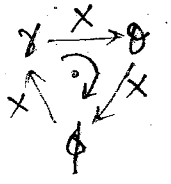
- $\hat{a_\rho} \times \hat{a_\phi} = \hat{a_z}$
- $\hat{a_r} \times \hat{a_\theta} = \hat{a_\phi}$

c) The direction of third unit vector can be found using Right hand Curl Rule



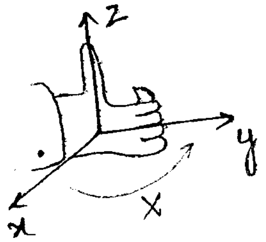
Ca Co Sys

Cy Co Sys



Sp Co Sys

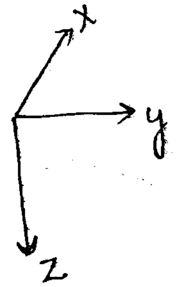
Right Hand Curl Rule:



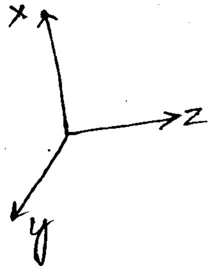
RH curl thumb

X → Y ≅ Z

Ex 1:



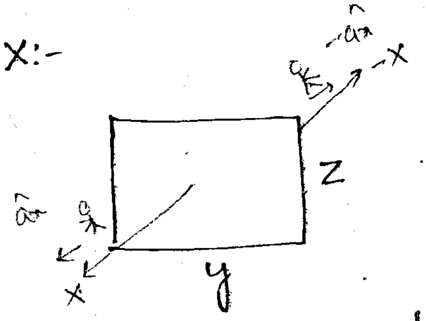
Ex 2:

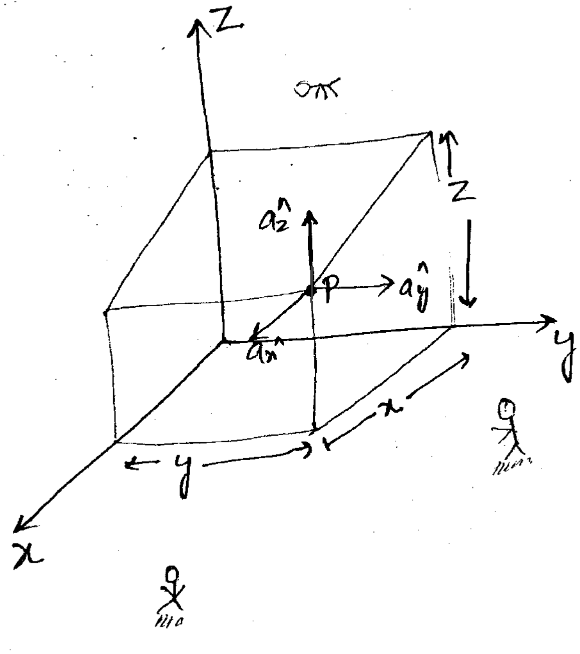


I) Cartesian coordinate system {x, y, z}

$$A_p = A_x \hat{a_x} + A_y \hat{a_y} + A_z \hat{a_z}$$

X:-

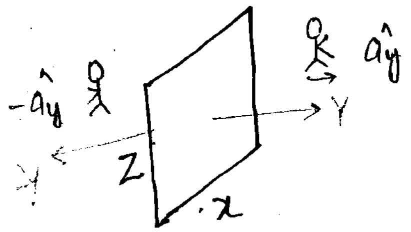




yZ plane
(or)
x = K ; K∈I } Ref

- Perpendicular distance from YZ plane is X
- Range of X, (−∞, ∞)
- Unit normal vector from YZ plane se X = K, K∈I is $\pm\hat{a_x}$

Y:-

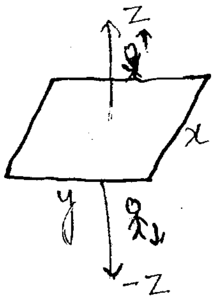


xz plane $Y=K$ $K \in I$ (ref)

- Perpendicular distance from xz plane is Y
- Range of $Y: (-\infty, \infty)$
- Unit Normal vector from xz plane

  ie $Y=K$ $K \in I$ is $\pm \hat{a}_y$

Z:-



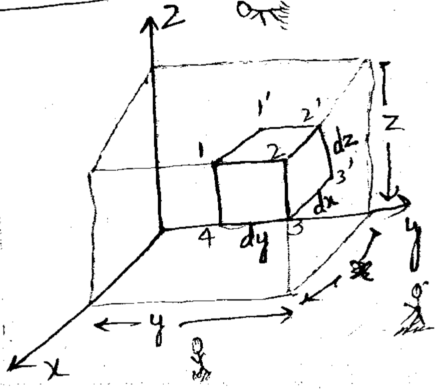
xy plane (or) $Z=K, K \in I$ (Ref)

- Perpendicular distance from XY Plane is Z
- Range of $Z: (-\infty, \infty)$
- Unit normal vector from XY plane ie

  $Z=K$ $K \in I$ is $\pm \hat{a}_z$

Concept of differential length, Area and volume

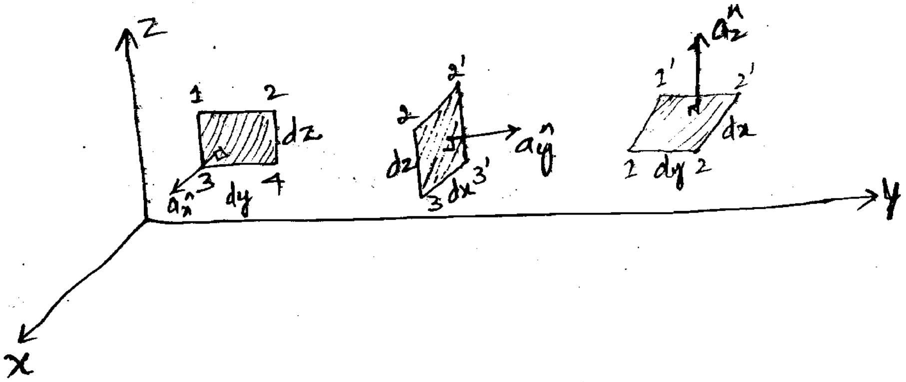
[Graphical Approach]



i) Differential length : $\vec{dl} = dx\,\hat{a_x} + dy\,\hat{a_y} + dz\,\hat{a_z}$

ii) Differential Surface area

$$ds = dy\,dz\ \hat{a_x}$$
$$= dx\,dz\ \hat{a_y}$$
$$= dx\,dy\ \hat{a_z}$$



iii) Differential volume

$$dv = dx\,dy\,dz$$

<u>Analytical Approach</u>

$$dl = dx\,\hat{a_x} + dy\,\hat{a_y} + dz\,\hat{a_z}$$
$$= 1 * dx\,\hat{a_x} + 1 * dy\,\hat{a_y} + 1 * dz\,\hat{a_z}$$
$$= h_1 * dx\,\hat{a_x} + h_2 * dy\,\hat{a_y} + h_3 * dz\,\hat{a_z}$$
$$= h_1\,du\,\hat{a_u} + h_2\,dv\,\hat{a_v} + h_3\,dw\,\hat{a_w}$$

h_1, h_2, h_3 = Scaling factor

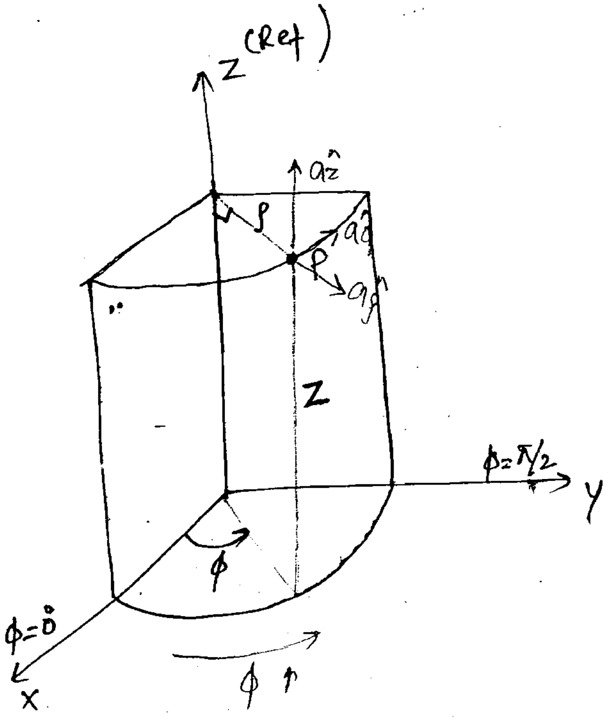
u, v, w parameters

	Parameters			Scaling factor		
	U	V	W	h_1	h_2	h_3
Ca Co Sys	x	y	z	1	1	1

اگر Area 'x' کی direction میں
لگانا ہو تو 'x' کو Freeze
کرینگے باقی دونوں کو multiply
کرینگے dy dz ân

II Cylindrical co ordinate System

$$\vec{A_p} = A_\rho \hat{a_\rho} + A_\phi \hat{a_\phi} + A_z \hat{a_z}$$



ρ:-

- Radial or perpendicular distance of point from a reference axis (z-axis)
- Range of ρ: [0 → ∞]

Physical significance of perpendicular distance in ρ:

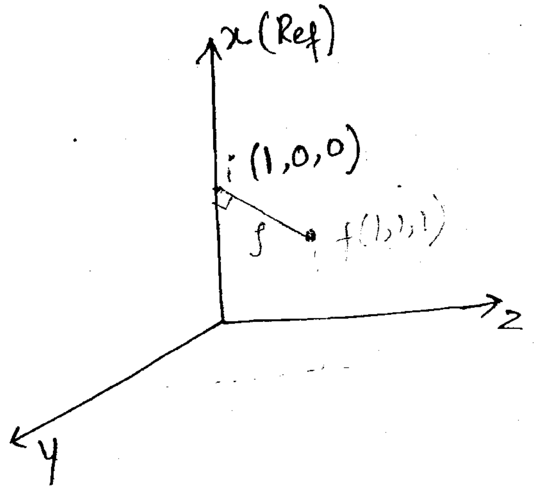
Ex 1:

Axis is along x axis

f (1,1,1)

i(?)

provided the final point from initial point is perpendicular to x axis.



MADE EASY

ELECTRICAL ENGINEERING

E.M.I

By.Bala JI Sir

- Theory
- Explanation
- Derivation
- Example
- Shortcuts
- Previous Years Question With Solution

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

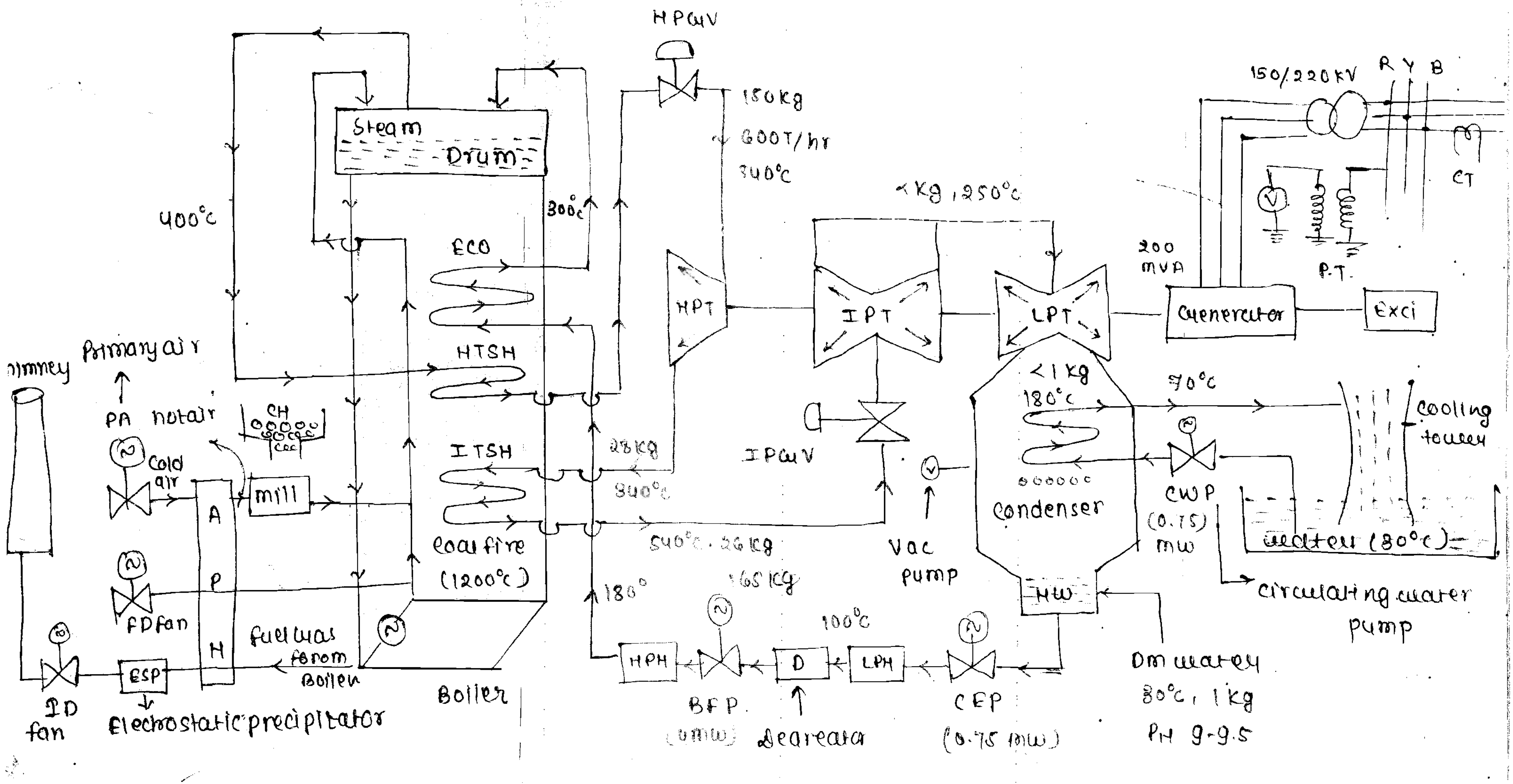
Thermal power plant

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

Principle - Rankine cycle.
(Reheating of steam)

- DM - Deminiralize 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 water, water and steam.
- HTSH = High temperature super heater (steam will pass & its temp raise to 540°c)
- HPGV = High pressure governing valve, IPGV = Intermediate pressure governing valve
- ITSH = Intermediate temperature super heater
- ESP = electrostatic precipitation
- ESP = collection of air particle
- ID fan (Induced fan) - taking flue gases from boiler.
- for sending coal into boiler moisture has to remove so for this we use air pre heater (APH) (moisture absorbed by hot air)
- Transportation cost is very high for thermal plant.
- BFP - Highest pressure pump
- 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


HPCV
150 kg
600T/hr
540°C
<1 kg, 250°C
150/220 kV
R Y B
CT
P.T.
200 MVA
Generator
Exci
Steam Drum
400°C
300°C
ECO
HTSH
ITSH
coal fire (1200°C)
HPT
IPT
LPT
IPCV
28 kg
340°C
540°C, 26 kg
<1 kg
180°C
70°C
condenser
cooling tower
CWP
(0.75) MW
water (80°C)
circulating water pump
Vac pump
HW
DM water
80°C, 1 kg
PH 9-9.5
CEP
(0.75 MW)
LPH
100°C
D
Deareata
165 kg
BFP
(MW)
HPH
180°
Boiler
flue gas from boiler
A
P
H
mill
CH
coal
PA hot air
Primary air
cold air
FD fan
ESP
Electrostatic precipitator
ID fan
chimney

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

$$= \underset{90\%}{\underset{\downarrow}{\eta_B}} \times \underset{30\text{-}40\%}{\underset{\downarrow}{\eta_T}} \times \underset{90\%}{\underset{\downarrow}{\eta_G}}$$

now η due to condence heat loss

Bituminous coal used

Coal chemical / heat Energy

= calorific value ⇒ C_F ⇒ Kcal

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

Practical

$\eta_{thermal} = 40\%$

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

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

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

Generator - 200 mw , 1 day - 24 hrs

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

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

(1) C_F in kcal/kg

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

2) C_F is kwhr/kg

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

MADE EASY

ELECTRICAL ENGINEERING

Signal & System

By.Rohit Tripathi Sir

- Theory
- Explanation
- Derivation
- Example
- Shortcuts
- Previous Years Question With Solution

Chapters :-

1. signals definition and its classification
    - → Even / Odd
    - → Periodic / Non-periodic
    - → cojugate symmetric & conjugate anti symmetri
    - → Half wave symmetry
    - → Energy and Power signal
2. Different operations in signal
    - → shifting
    - → scaling
    - → Reversal
    - → Differentiation
    - → Integration
    - → convolution
3. Basic system properties
    - → static / dynamic system
    - → Linear / non-linear
    - → Causal / Non-causal
    - → Stable / unstable
    - → Time 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 → 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

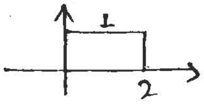
12. Discrete cosine transform (DCT)
→ IES only.

II. Different operations on signal :-

(1) Time shifting :-

→ Left shifting
→ Right shifting

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



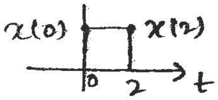
Case (i) :- When $k>0$ (Left shifting) :-

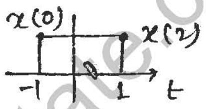
Example $k=1$

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

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

$t=1$ $x(2)$





(Left shifting)

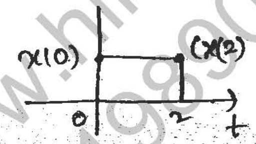
Case (ii) :- When $k<0$ (Right shifting) :-

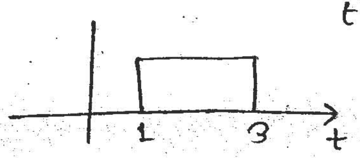
Example $k=-1$

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

$t=1$ $x(0)$

$t=3$ $x(2)$



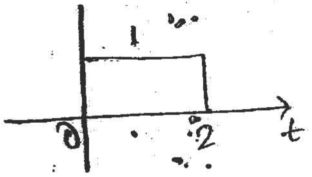


(Right shifting)

(2) Amplitude shifting :-

→ upward
→ downward

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



Case (i) <u>when $k>0$</u> (upward shifting)

Example $k=1$

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

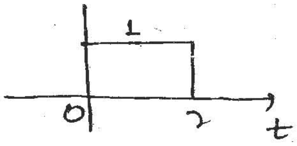
$$x(t) = \begin{cases} 0 \; ; & t<0 \\ 1 \; ; & 0 \le t \le 2 \\ 0 \; ; & t>2 \end{cases}$$

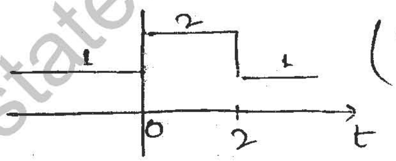
$$y(t) = 1 + x(t)$$

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

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

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





(upward shifting)

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

Example $k=-1$

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

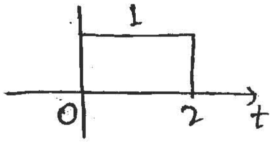
$$x(t) = \begin{cases} 0 \; ; & t<0 \\ 1 \; ; & 0 \le t \le 2 \\ 0 \; ; & t>2 \end{cases}$$

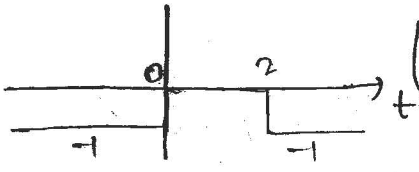
$$y(t) = -1 + x(t)$$

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

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

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





(Downward shifting)

MADE EASY
ELECTRICAL ENGINEERING
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 , complimentary)
~~3)~~ ↓ Buffer ↓ NOT

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

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

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

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

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

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

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

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

		$S_2 \oplus S_1$
S_2	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.

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

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

→ $f_9 = x \odot y$ $\boxed{\text{Ex-NOR}}$

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

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

→ $f_{10} = \overline{y}$ $\boxed{\text{NOT}}$

→ $f_{11} = x + \overline{y}$ $\boxed{\text{Implication}}$

→ $f_{12} = \overline{x}$ $\boxed{\text{NOT}}$

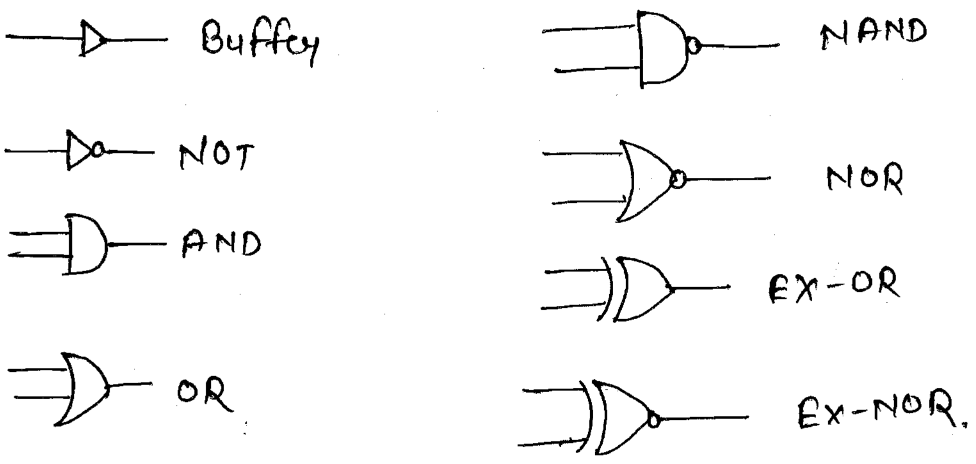
→ $f_{13} = \overline{x} + y$ $\boxed{\text{Implication}}$

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

$x \uparrow y$

→ $f_{15} = 1$ $\boxed{\text{Identity}}$

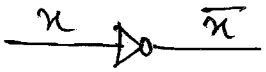
Logic Gate Symbols

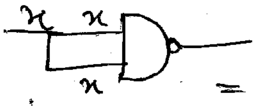


→ Basic logic gates — NOT, AND, OR

Universal logic gates— NAND, NOR

E.g.





$\overline{x \cdot x}$

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

$= \overline{x}$

Trick / short-cut.

NAND $\overset{\longrightarrow}{\underset{\longleftarrow}{4}}$ NOR

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

Duality

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

Step-2 Interchange the identity $\rightarrow (0, 1)$

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

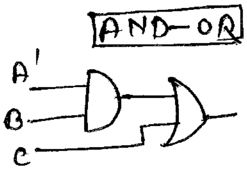
E.g. i) $x \cdot 0 = 0$

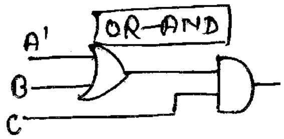
$x + 1 = 1$

ii) $F = A'B + C$

$F^D = ?$

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

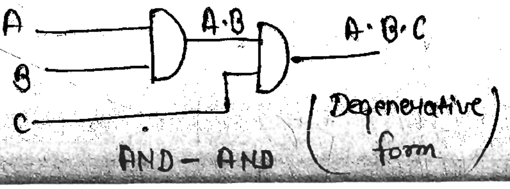


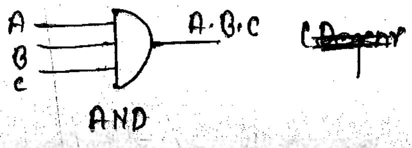


Degenerative forms

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

E.g.





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ELECTRICAL ENGINEERING

Control System

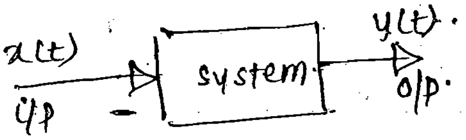
By.Haneef Sir

- Theory
- Explanation
- Derivation
- Example
- Shortcuts
- Previous Years Question With Solution

Control System

(*) System:- It is a means of transforming change a signal.

Signal is a fn of one or more independent variable. We are representing it with f(t).



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

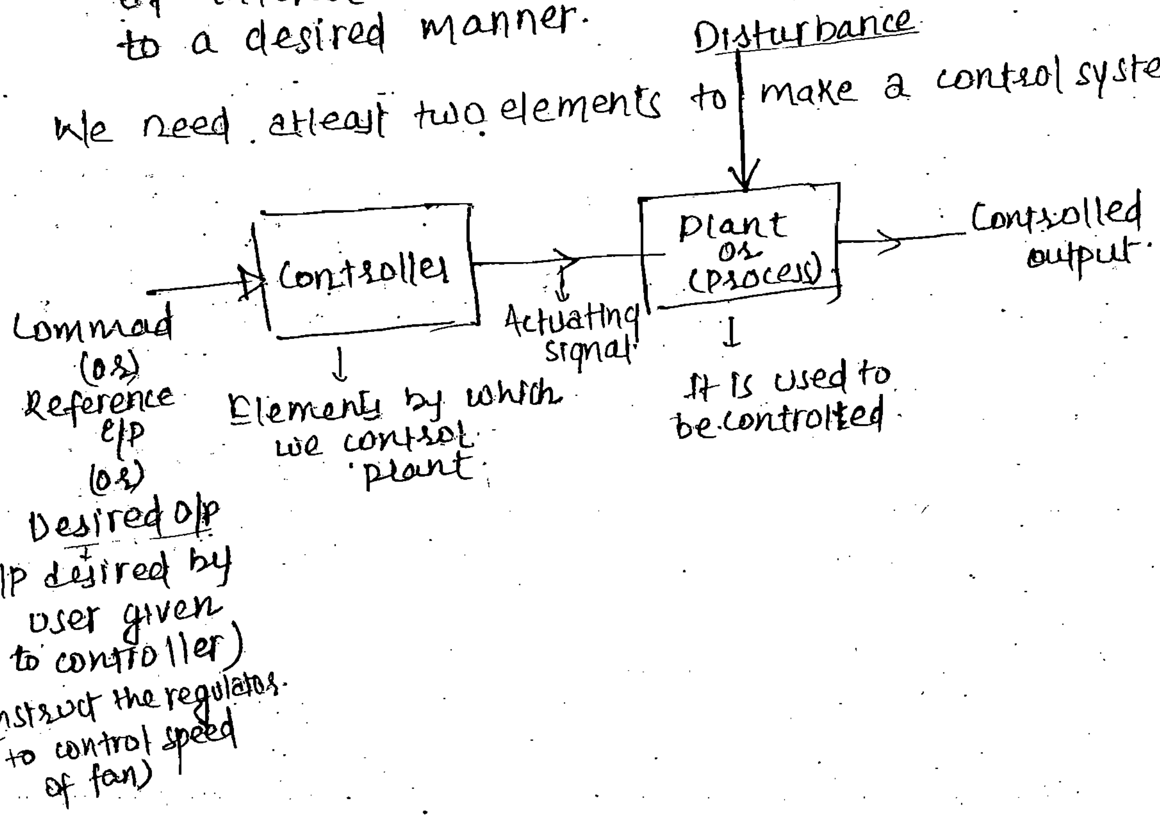
T, transformation.

(*) Control System:- (slave). It is a system which produces desired o/p for a given i/p.

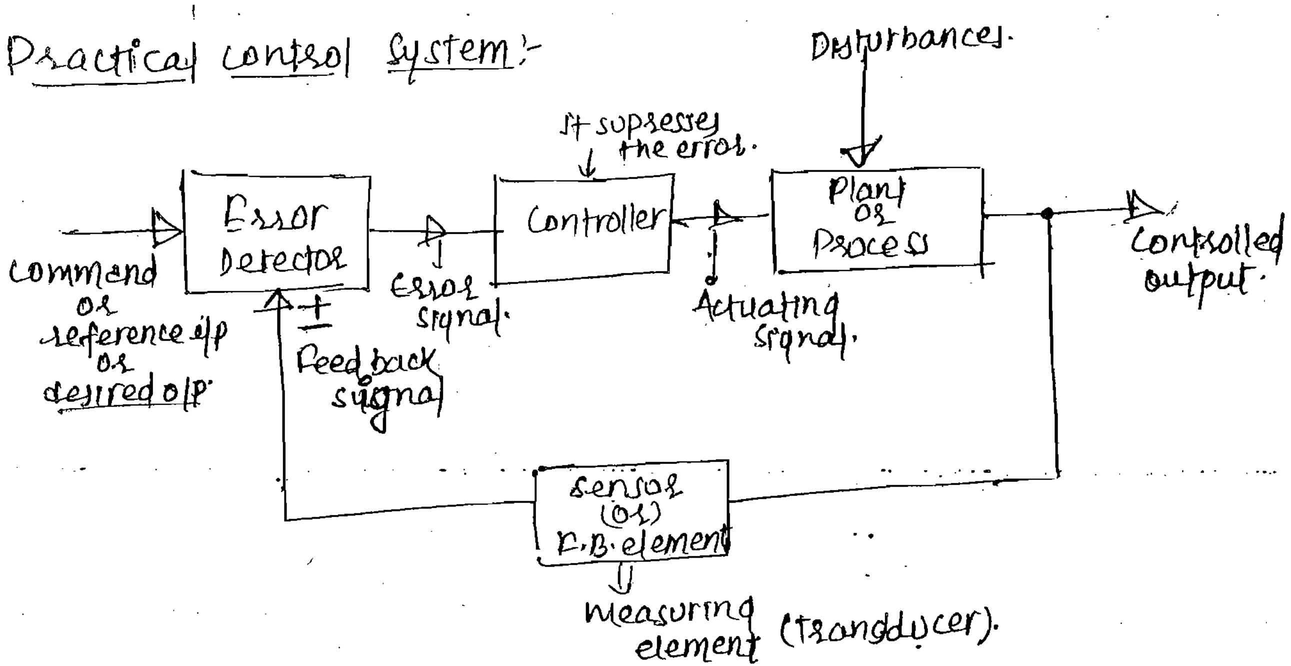
→ o/p of a system can be controlled by user in control system.

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

We need atleast two elements to make a control system.



⊛ Practical control system:-



C o/p

→ The objective of any control system is to ensure that the controlled o/p becomes same as the command or desired o/p. This state of system is known as steady state. But if any disturbance occours then the controlled o/p differs from set value. To restore the o/p to its original value. control system is modified as shown above.

→ Error detector with the help of sensor produces error signal which the difference b/w desired o/p and actual o/p, which is supressed by the controller. Hence the effect of disturbance is removed from control system. It is used to identify the disturbances offered by plant not of its ~~self~~ own disturbances.

→ A control system can reach to steady state with 100% o/p only at $t \to \infty$. because controlled system is designed s.t. disturbance effect associated with the plant is eliminated but disturbances associated with other parts may still be present.

$10V = 10\angle 0°$ → +ve feedback signal

$-10V = 10\angle 180$ → -ve feedback "

only phase shift.

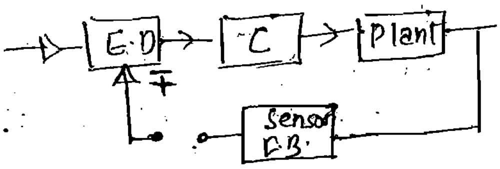
→ Feedback in control system is employed mainly to improve its accuracy but it also affects other characteristics of s/y. like Gain, B.W, speed, stability, sensitivity, etc.

$$\uparrow \underset{[\text{Effect}]}{y} = \overset{+}{m}x \underset{[\text{cause}]}{\uparrow} \rightarrow +\text{ve feedback.}$$

$$\downarrow \underset{[\text{Effect}}{y} = mx \underset{[\text{cause}]}{\uparrow} \rightarrow -\text{ve feedback.}$$

Control System

NFBCS / OLCS.



Sensor without sense.

eg:- A blind man with eye but without vision.

→ Washing machine

→ The o/p of the system is made independent of sensor or feedback.

FBCS / CLCS.

- Man-machine
- Automatic

Signal will be circulated along a closed path.

→ One which man & machine closes the loop together.

→ Machine alone forms the close loop.

→ We need to make open loop system first then Human involves and closes the loop.

⊛ Differences b/w the performance of an open loop C.S and a CL control system.

Open loop C.S.	Close-Loop C.S.
1. The behaviour of the open loop system doesn't change if its o/p changes hence OLCS is not accurate.	1. The behaviour of CLCS does change if its o/p changes hence CLCS is accurate.
2. In open-loop system sense is not present but usually sensor is present.	2. In close-loop system sense is always present either manually or automatically.
3. Time constant of OLCS, is larger due to which transients takes large time to die out hence OLCS is slow.	3. Time constant of CLCS is smaller due to which transients die out rapidly hence CLCS is fast.

4. The affect of external disturbance and internal parameter variation is more in OLCS. i.e. OLCS is more sensitive.	4. The affect of external disturbance and internal parameter variation is less in close loop system i.e. CLCS is less sensitive.
5. OLCS is simple and economical.	5. CLCS is complex and expensive.
6. Open loop-system is usually stable but can't be establized if become unstable.	6. C.L.C.S can become unstable but can be stabalized.

→ Only stable system can reach steady state.

Q. If a OLCS is stable, and if we apply -ve feedback to it then what can be ~~is~~ say abt stability of system.

→ The stability of system can't be determined excatly it can increase or decrease.

Note:- 1. No feedback gurantees stability whereas -ve feedback gives better stability as compared to +ve feedback.

2. Inspite of having -ve F.B C.S. can still become ustable due to:

① High open loop gain.
② High type no.
③ High sensitivity.
④ High transportation delay (or) Lag phase.

⊛ Differences b/w -ve and +ve feedback system:-

Performance criteria	-ve F.B system	+ve F.B system
1. Gain.	↓	↑
2. B.W.	↑	↓
3. Time constant	↓	↑
4. Speed	↑	↓

5. Sensitivity	↓	↑
6. Stability	↑	↓

As. Gain × B.W = K
V × I = K,
Speed × Torque = K.
→ Ep × P.D = K.

→ C.S. was invented in year 1710 → steam engine (Fly ball) to control speed of

Syllabus :-

Mathematical Analysis of C.S.:-

→ Based on two standard Mathematical Model:-

1. T.F. Model. (Classical Method) → (LTI)
2. State Model. (Modern Method) → (Any system)

↔	To Domain	Freq. Domain
✓ Cont. Time	L.T	F.T.
Disterete Time.	Z.T	DTFT.

⊛ Transfer Function [T.F] :-

→ T.F. is ratio of output and input variables such that initial codn are zero. (initially relaxed system)

since, Total Response $= \overset{0}{\cancel{ZIR}} + ZSR$ → Dynamic (or) transient state. → static (or) steady state.

↓ (due to initial codn) (i/p)

$$T.F = \frac{L[IR]}{L[\delta(t)]} = \frac{L[SR]}{L[u(t)]} = \frac{L[RR]}{L[t\,u(t)]} = \frac{L[PR]}{L[\frac{t^2}{2}u(t)]}.$$

↓ changed by changing the componets of system.

$$= L[IR] = sL[SR] = s^2L[R\cdot R] = s^3L[PR].$$

Note:- Transfer Fn of a system is ~~const same~~ unique. But two systems can have same transfer fn. but for a single system there is only one T.F.

2. T.F. always depends only on system components. It doesn't depend on input and o/p of system.

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ELECTRICAL ENGINEERING
Analog Electronics
By.A.Rajkumar Sir

Subject : Analog Electronics

COURSE DETAILS : ① Diodes – [P-n diodes , Zener diodes*]

② BJT [Testing*, Biasing , Amplifiers*]

③ Op-Amp [Multistage basics , Differential Amplifier, Op-amp Applications*]

④ FET [JFET , MOSFET] [Testing , Biasing*, Amplifiers]

IMPORTANT TOPICS :

DIODES

① DC Equivalent model of diode

② AC equivalent model of diode

③ Clippers , peak detectors, clamper, Voltage multiplier

④ Zener Regulators

BJT

*① Testing (Dual battery)

② Biasing (BJT, FET)

*③*Current Mirror biasing techniques

*④ BJT & MOSFET Amplifiers

OP-AMP

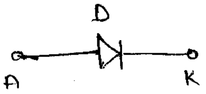
① Amplifier designs

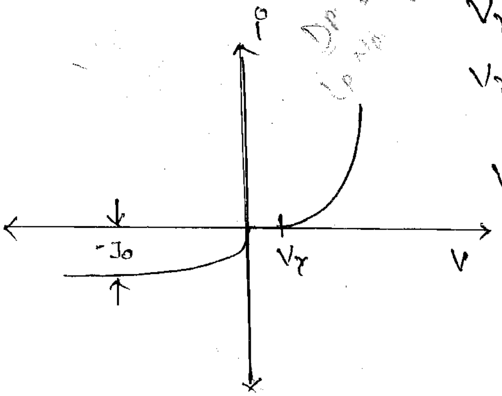
② Mathematical operations

③ Non-linear .

DIODES

1) DIODE CURRENT EQUATION [V-I CHARACTERISTICS]





V_γ - cut in - voltage

$$V_\gamma = V_T \ln\left[\frac{N_A \cdot N_D}{n_i^2}\right]$$

$V_\gamma[Ge] = 0.1V$ to $0.3V$

$V_\gamma[Si] = 0.5V$ to $0.7V$

I_o - Reverse saturated current (or) Leakge current (or) Minor current

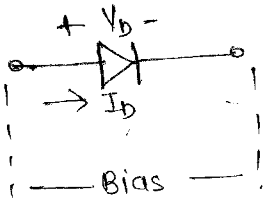
$\boxed{I_o \propto Area}$ $\boxed{I_o \propto \frac{1}{\text{Doping Concentration}}}$ $\boxed{I_o \propto Temperature}$

$$I_o = Aq\left[\frac{D_P}{L_p N_D} + \frac{D_A}{L_n N_A}\right] n_i^2$$

$I_o[Ge] \rightarrow \mu A$ $I_o[Si] = nA$

$Si \rightarrow T_{Limit}[200°C]$ $Ge \rightarrow T_{Limit}[300°C]$

$$\Rightarrow I_D = I_o\left[e^{V_D/\eta V_T} - 1\right]$$

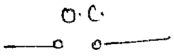


where

I_D = Total current through a diode

I_o = Leakage current

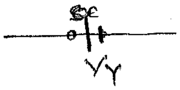
V_D = Voltage drop accross diode



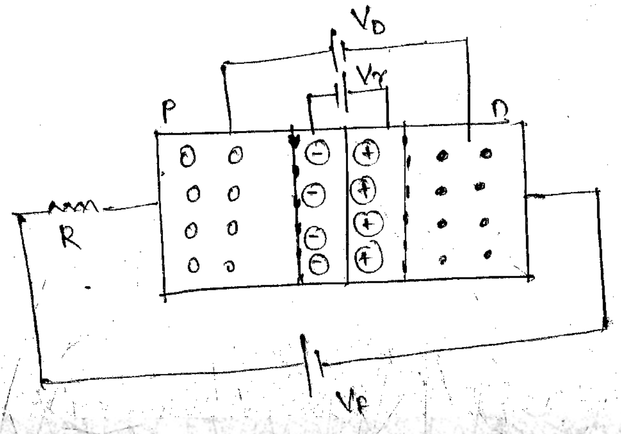
$V_D = V_F$ or V_R

$\rightarrow V_F < V_\gamma$ D OFF

$V_F \geq V_\gamma$ D ON



$V_D = V_\gamma$



η = Idealised factor

$\eta = [1]$ Si ↓ for integrated diodes

$\eta = [2]$ Si ↓ for one diode

→ V_T = Thermal voltage or volt eq. temperature

$V_T = \frac{KT}{q} = \frac{T}{q/K}$

$\therefore \boxed{V_T = \frac{T}{11,600} \text{ Volts}}$

FORWARD BIAS: $V_F \geq V_\gamma$

$I_D = I_0 [e^{V_D/V_T} - 1]$

$V_D = V_\gamma = 0.7V$ [Si]

$V_T = \frac{300K}{11,600}$ [27°C]

$V_T = 25$ mVolt

$I_D = I_0 [e^{0.7/25 \times 10^{-3}} - 1]$

$I_D = I_0 [e^{\frac{700mV}{25mV}} \cancel{-1}]$

$\boxed{I_D = I_0 e^{V_D/V_T}}$ → exponential $[I_D]$

$V_D = V_T \ln\left(\frac{I_D}{I_0}\right)$ → log $[V_D]$

REVERSE BIAS

$I_D = I_0 [e^{V_D/V_T} - 1]$

$V_D = V_R = -1V$

$V_T = \frac{300k}{11,600}$ (27°C) = 25mVolt

$I_D = I_0 \left[e^{\frac{-1V}{25mV}} - 1\right]$

$I_D = I_0 \left[e^{-\frac{1000mV}{25mV}} - 1\right]$

$I_D = I_0 \left[e^{\frac{1}{\frac{1000mV}{25mV}}} - 1\right]$

$\boxed{I_D = -I_0}$

ANALYSIS

1) V_T is nearly constant for 10°c rise in temperature.

$T_1 = 27°c$ $V_{T_1} = \frac{300K}{11,600} = 25mV$

$T_2 = 37°c$ $V_{T_2} = \frac{310k}{11,600} = 26mV$

2) I_0 increases by 7%/°c rise in temperature

(OR)

I_0 doubles for every 10°c rise in temperature.

$\boxed{I_{02} = I_{01} \, 2^{\frac{(T_2 - T_1)}{10}}}$

$T_1 = 27°C$ $T_2 = 37°C$

$I_{01} = 10nA$ $I_{02} = ?$

$I_{02} = I_{01} \, 2^{(T_2 - T_1)/10}$ ⇒ $I_{02} = 20nA$

3) V_D decreases by −2.5mV/°c rise in temperature

$\frac{\partial V_D}{\partial T} = -2.5mV/°c$

$V_D = V_T \ln\left(\frac{I_D}{I_0}\right)$ I_D → Battery, I_0 → Temp

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Material Science
By.V.kumar Sir

- Theory
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2020 Technical Material science for ECE and EEE

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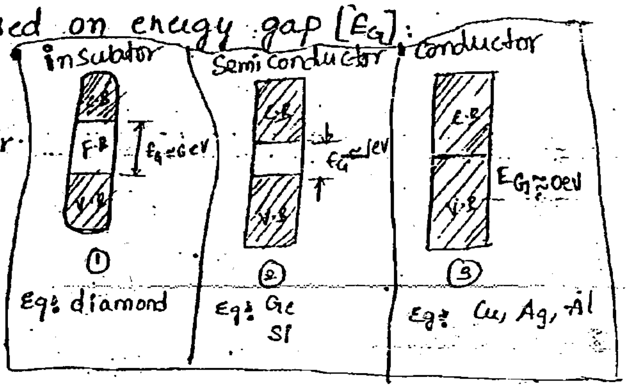
Basics of material science.

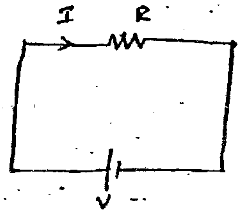
2. Conductor Materials

Note:- Classification of materials based on energy gap $[E_G]$:

1) Insulator
2) Semi-conductor
3) Conductor



Ohm's Law Of Electricity :-



V is the applied voltage

I is the produced current

R is the resistance of a resistor

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

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

$$V = \text{constant} \times I$$

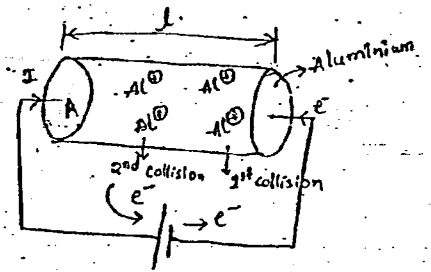
$$V = RI \quad \text{—①}$$

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

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

$\rho \Rightarrow$ electrical resistivity (Ωm)

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



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

l = length of conductor

A = Cross sectional area

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

$$F = ma \quad \text{——③}$$

Force on electron having 'q' charge due to applied electric field intensity 'E' is $\vec{F} = q\vec{E} \rightarrow ④$

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

Drift velocity $v_d = a\tau_c$ —— ⑥

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

Put ⑤ in ⑥

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

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

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

$$\boxed{\vec{v}_d = \mu\vec{E}}$$

$$\boxed{\mu = \text{mobility} = \frac{q\tau_c}{m} \left[\frac{m^2}{(\text{Volt})(\text{sec})}\right]}$$

$$\underset{\left(\frac{A}{m^2}\right)}{\vec{J}} = \underset{\left(\frac{1}{m^3}\right)}{n}\,\underset{(C)}{q}\,\underset{\left(\frac{m}{sec}\right)}{\vec{v}_d} \quad \text{—— ⑧}$$

Put ⑦ in ⑧

$$\vec{J} = nq\mu\vec{E} \quad \text{—— ⑨}$$

Compare ② and ⑨

$$\sigma = nq\mu \quad \text{—— ⑩}$$

$$\sigma = nq\left(\frac{q\tau_c}{m}\right)$$

$$\boxed{\sigma = \frac{nq^2\tau_c}{m}}$$

n = electron density = $\frac{\text{number of electrons}}{m^3}$ $\left(\frac{1}{m^3}\right)$

q = charge of charge particle.

m = mass of charge particle.

τ_c = collision time (second).

τ_c is the average time b/w two successive collisions

NOTE: ** ① In conductor (or) metals when temperature is increased metal ions vibrate and number of collisions increase and collision time decreases, so conductivity decreases and resistivity increases. Metals have positive temperature coefficient of resistivity and resistance.

It is found that $\tau_c \propto \frac{1}{\sqrt{T}}$

$$\sigma \propto n\tau_c .$$

$$\sigma \propto \frac{n}{\sqrt{T}}$$

T = temperature

Factors affecting the resistivity :

*① temperature (T) : In conductor the temperature is increased the ρ increase according to the following equation

$$\boxed{\rho_T = \rho_{RT}\,(1+\alpha \Delta T)} \text{ — ①} \quad \text{also } \boxed{R_T = R_{RT}\,(1+\alpha \Delta T)}$$

ρ_T = resistivity of operating temperature

ρ_{RT} = Resistivity at room temperature (T_{RT})

$\Delta T = T - T_{RT}$

ΔT = Change of temperature

α = temperature coefficient of resistivity ($1/{}^\circ C$ or $1/{}^\circ K$)

α is positive for metals

$R_T \Rightarrow$ Resistance at T temperature

$R_{RT} \rightarrow$ Resistance at Room temp (or) Reference temp.

$\Delta T = T - T_{RT} = \left\{\begin{matrix}\text{change of} \\ \text{temp}\end{matrix}\right.$

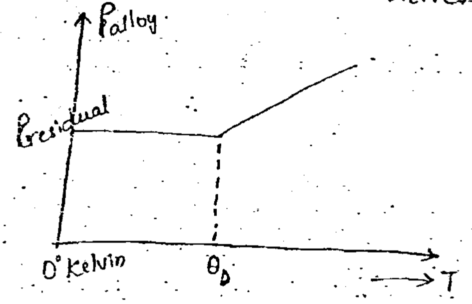
α = temperature coefficient of Resistance ($1/{}^\circ C$)

*② Alloying Effect : Adding impurity atoms to pure metals.

If percentage of alloy content is increased then irregular in atomic arrangement increases, so resistivity increases (independent of temperature) This is called as residual resistivity ($\rho_{residual}$)

Total resistivity is $\boxed{\rho_{alloy} = \rho_{thermal} + \rho_{residual}}$ — ②

Eqn ② is called as matthiessen rule.



θ_D is called as Debye temperature. It is the temperature after which ρ increases linearly w.r.t temperature

③** Deformation :

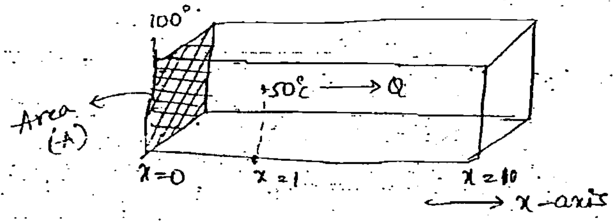
Deformation → change of shape (or) length (or) diameter (or) volume.

⇒ Deformation in conductors increases the Irregularity of atomic arrangement . so ρ increases. This increase of ρ is called as $\rho_{deformation}$ for alloy having deformation

Total resistivity $\rho_{alloy} = \rho_{thermal} + \underbrace{\rho_{residual} + \rho_{deformation}}_{\text{permanent i.e. independent of temperature}}$.

Observation :

1) In conductors (or) metals thermal energy is transferred due to random motion of free electrons as well as vibrations of metal ions. But most of the % of ~~thermal~~ energy is transferred due to free electrons. In conductors the (Q) thermal power crossing the area is given by



$$Q = -k\frac{dT}{dx}\left(\frac{watt}{m^2}\right) \text{ — ①}$$

$$\frac{dT}{dx} = \text{temperature gradient}\left(\frac{°kelvin}{m}\right)$$

where k is thermal conductivity $\left(\frac{watt}{°k \cdot m}\right)$

for conductors k due to free e-s is given by

$$k = \frac{1}{3}\frac{n\pi^2 K^2 T \tau_c}{m} \text{ — ②}$$

for conductors $\sigma = \frac{nq^2\tau_c}{m}$ — ③

$$\frac{②}{③} \quad \frac{k}{\sigma} = \frac{\frac{\frac{1}{3}\cancel{n}\pi^2 K^2 T \cancel{\tau_c}}{\cancel{m}}}{\frac{\cancel{n}q^2\cancel{\tau_c}}{\cancel{m}}}$$

$$\frac{k}{\sigma T} = \frac{1}{3}\frac{\pi^2 k^2}{q^2}$$ | K is Boltzmann Constant
| q is charge of electoion

after substituting values we get

$$\boxed{\begin{array}{c} \frac{k}{\sigma T} = 2.45 \times 10^{-8} \\ \frac{k}{\sigma T} = L \end{array}} \text{———} ④$$

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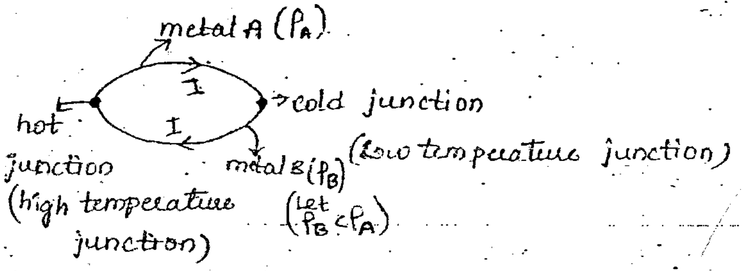
$L = 2.45 \times 10^{-8}$ = Lorentz number.

Eqⁿ ④ is called as weidemann Franz law of conductors, which says the ratio of thermal conductivity (k) and electrical conduct (σ) at any temperature (T) is constant

**
Thermoelectric Effects:

*Seebeck effect:-



If two dissimilar metals (A, B) having different resistivities are joined. If one end is maintained at high temperature, other is maintained at low temperature then electromotive force (emf) is produced. This emf makes the current flow in the loop. This is called as seebeck effect. ⇒ Seebeck invented thermocoupl

*Peltier Effect:- (converse of seebeck Effect)

If two dissimilar metals are joined, if current is flown in the loop then one junction goes to high temperature and other junction goes to low temperature. This is called peltier Effect. Peltier effect is used in refrigerator.

Types of Conductors:

**) Low resistivity conductors:

These are used in tramission and distribution of electrical current. Ex: Copper (Cu), Aluminium (Al).

**2) High resistivity conductors:

These are used in manufacturing resistors, electrical heating devices, thermocouples. These materials must withstand high temperature. They are generally alloys of metals.

Ex: Constantan (60% Cu, 40% Ni)

Nichrome [75 to 78% Ni
20 to 30% Cr
1.5% Mn
remaining is Fe]

** ⑧ Low melting point conductors:

Metals having low melting point are used in soldering joints.
Ex: tin, lead (Pb)

→ Soldering materials [Tin(Sn), Lead (Pb)] have low melting point and high electrical conductivity.

**Note:- Tin (Sn): (i) tin is a silvery white (or) shining white colour (ii) conductivity of tin is less (or) poor compared to copper ($\sigma_{Sn} = 0.917 \times 10^7 (\Omega\text{-m})^{-1}$ at 20°C) (iii) tin can be drawn into wires because it is soft and malleable (iv) tin is used in alloys with lead and copper (v) tin is used for fuses and cable sheathing. (vi) tin is corrosion Resistant because of formation of oxide layer.

ESE
Ⓠ A Resistor measures 4Ω at 40°C and 6Ω at 80°C. At 0°C the resistor will measure ⓐ 1.5Ω ⓑ 2Ω ⓒ 3Ω ⓓ 4Ω

→ $R_T = R_0(1+\alpha\Delta T)$ where R_0 is Resistance at 0°C and $\Delta T = T - 0$

at T = 40°C ⇒ $4 = R_0(1+\alpha 40)$ → ②
at T = 80°C ⇒ $6 = R_0(1+\alpha 80)$ → ③
② ÷ ③ ⇒ $\frac{4}{6} = \frac{1+40\alpha}{1+80\alpha}$ ⇒ $\alpha = \frac{1}{40}$ → ④

put ④ in ②
$4 = R_0(1+\frac{1}{40}40)$ ⇒ $R_0 = 2\Omega$

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Microprocessor
By.Vijay Sir

1947 - Transister

SSI → < 10 Transistor (small scale integration)

MSI → 10 - 100 Transistor (medium scale -" ——)

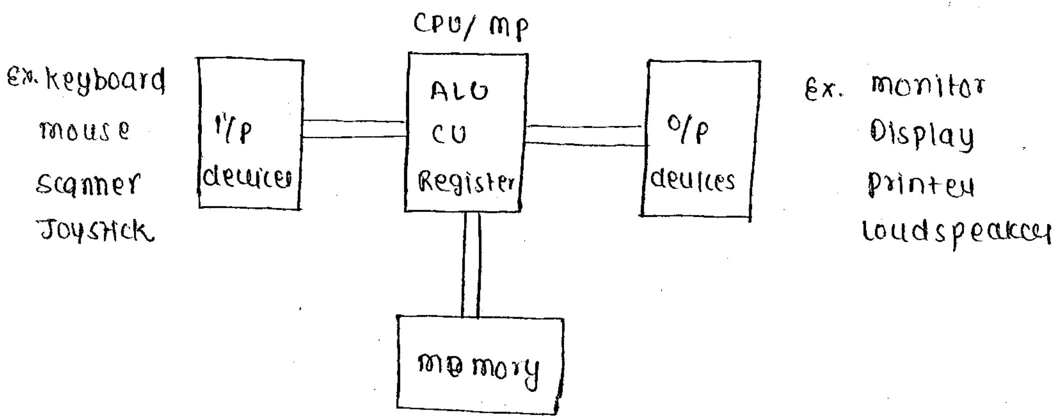
LSI → 100 - 10K Transistor (Large - " — " ——)

VLSI → > 10K Transistors (Very large - " ————) (✓)

ULSI → ⋮

SLSI → ⋮

Block diagram of a computer



Microprocessor

It is a semiconductor component designed by using VLSI Technology and it contains ALU, CU and Registers of a CP.U in a single palkage

NOTE- for a micro processor memory is connected exeternally, the Resistors inside the processor can not be considered as memory, As they are used to hold the data temperarily. Latest processor may have some memory inside to store frequently used data or instruction

Ex. Cache memory

Bit → Binary digit

→ 0/1

1 Nibble → 4 Bits

1 Byte → 8 Bits

word length → depends on type of µp

Wordlength

No. of Bits that can be processessed by a processor parallely at a time

Ex. 8 Bit µp → 8 bits (word length) / 1 Byte

16 Bit µp → 16 Bits / 2 Byte

32-" — → 4 Bytes

1971 → Intel 4004 → 4 Bit µp

1972 → Intel 8008 → 8 Bit µp

1974 → Intel 8080 → 8 Bits µp

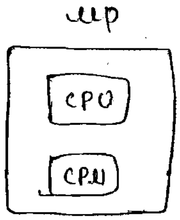
1977/78 → Intel 8085 → 8 Bit µp → Gate + IES

1979 → Intel 8086 → 16 Bit µp → IES

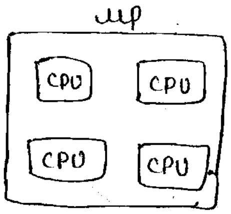
8088, 80186, 80286, 80386 [32 Bits]

Pentium ----- Dual core, ----- i3, i5, i7 (64 Bit

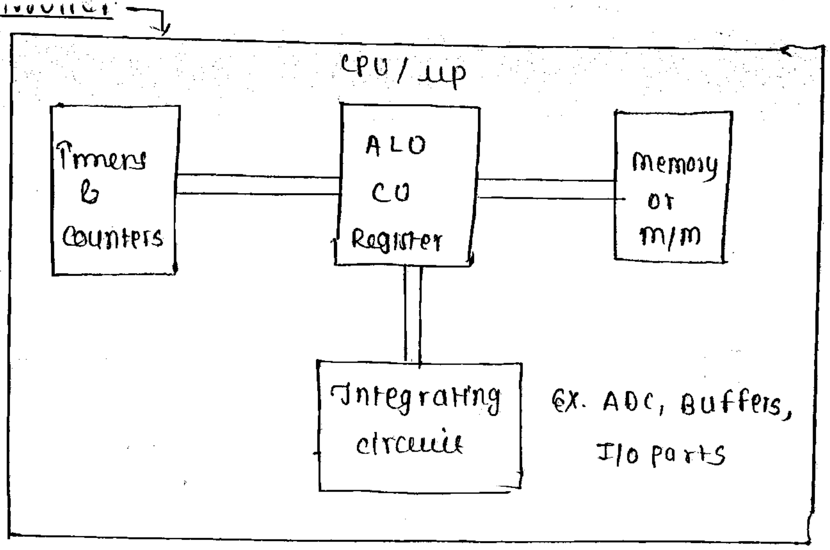
Dual core



Quad core



Micro controller →



Microprocessor (µP)	Microcontroller (µC)
(1) It has ALU, CU, Register	(1) It has ALU, CU, Registers
(2) No Internal memory (m/m)	(2) has Internal /on-Board m/m
(3) No interfacing circuit's Timers / counters	(3) has interfacing circuit, Timers / counters
(4) used for general purpose application	(4) Used for specific purpose or application
(5) Ex. Intel 8085, i7, - mc 6800, Zilog (Z80), AMD, Phillips, Toshiba, Qualcomm, national Semiconductors, Rockwell, fairchild	(5) Ex. TMS 1000 (4 Bit), Intel 8085 (8 Bi Intel 80196 (16 Bit), PIC → 8 Bit & 16 Bi AT89C51, Motorolla, phillips, Toshiba, Dallas semiconductors

Based on How programms and data are stored in the memory there are two types of Architecture

(1) Von-Neumann or princeton architecture
(2) Harvard Architecture

Von-Neumann or Princeton Architecture	Harvard Architecture
same memory for programme & data memory Programs & data Ex. Intel 8085 Intel 8086	seperate memory for programme & data (ROM) memory: Programs RAM memory: Data Ex. Intel 8051 (microcontroller

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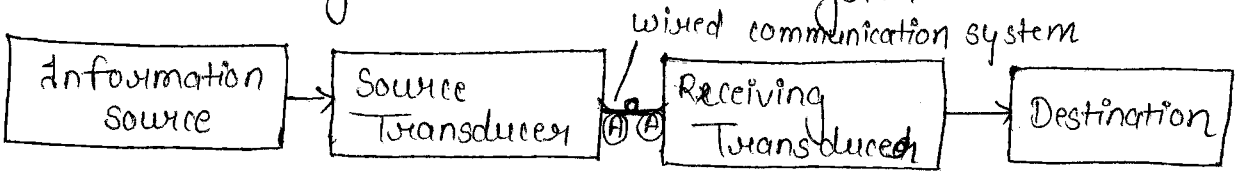
Communication System

By.Reddy Sir

Communication

" Communication is the process of transmitting information from one place to another."

Basic block diagram of communication system:

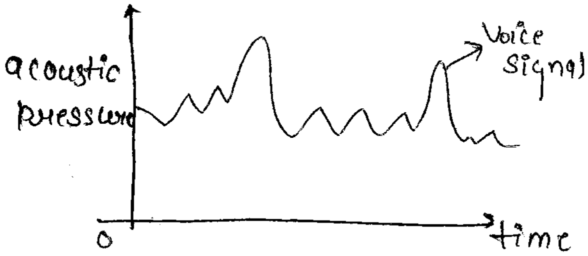


A → Amplifier

Voice Signal - 300 Hz - 3.5 kHz

Audio Signal - 20Hz - 20kHz

Video Signal - 0 - 4.5 MHz



Source Transducer:

It converts physical signal into electrical equivalent.

e.g - microphone

Wired communication system:

It is prefered only for short distance communication.

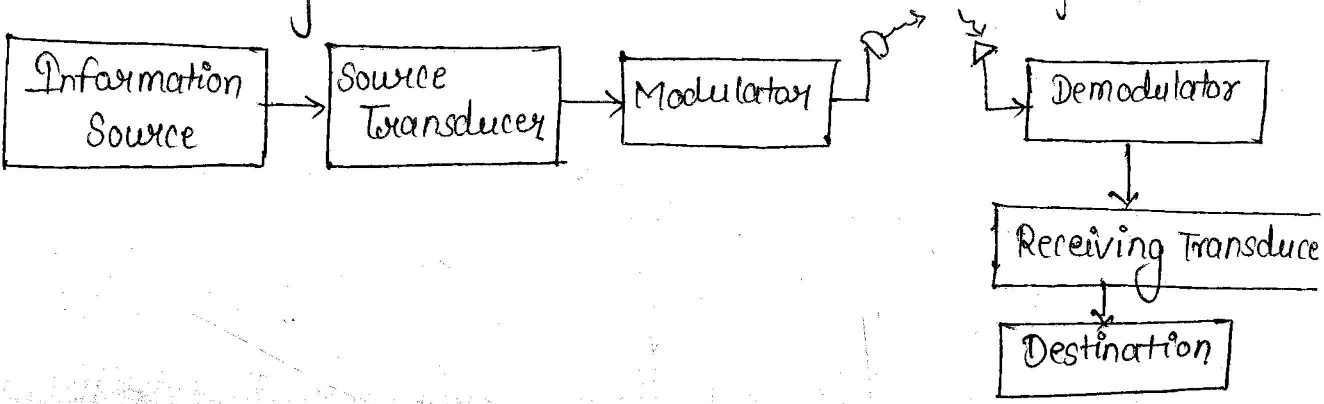
For long distance communication 'wireless Transmission' is preferred in which signal propagates through 'free space'.

Receiving Transducer:

It converts electrical signal into physical equivalent.

e.g. - loudspeaker.

Block Diagram of wireless communication system:



Generally without modulation long distance communication through free space is not possible.

Need for modulation -

1) Reducing antenna height :

$$\boxed{h_t = \frac{\lambda}{4}}$$

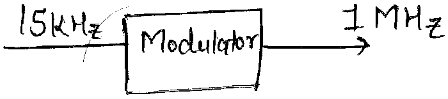
$\lambda = \frac{v}{f}$ $v = c$ $\boxed{\lambda = \frac{c}{f}}$

$$\boxed{h_t = \frac{c}{4f}}$$

i) $f = 15\ KHz$

$h_t = \frac{3 \times 10^8}{4 \times 15 \times 10^3} = 5\ Km$ (Practically not possible to construct antenna with this height)

ii)



$h_t = \frac{3 \times 10^8}{4 \times 10^6} = 75\ m.$ (Possible)

- for faithful radiation of a signal antenna height should be atleast of '$\lambda/4$'.
- Transmitting antenna converts electrical signal into electro magnetic, resulting propagates with light velocity.

NOTE -

Modulation is the process of increasing frequency of the signal to reduce antenna height requirements.

2) Multiplexing : It is the process of transmitting multiple number of signal through a single channel.

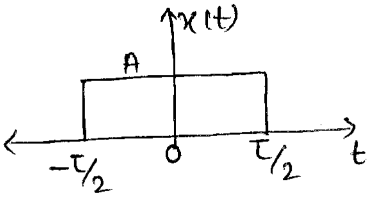
- Generally without modulation, multiplexing is not possible.

Fourier Transform:

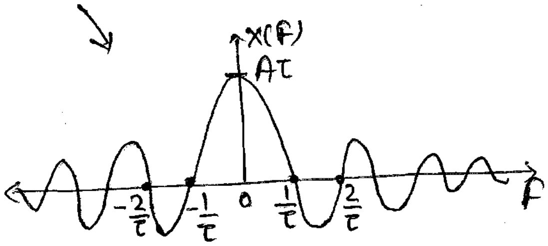
Fourier transform is basically used to find frequencies present in the given time domain signal.

$$x(t) \longrightarrow X(f)$$

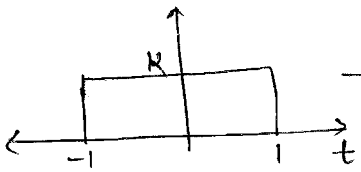
$$\boxed{X(f) = \int_{-\infty}^{\infty} x(t)\, e^{-j2\pi f t}\, dt}$$



$$\boxed{X(f) = A\tau \text{ sinc } (f\tau)}$$



E.g.



$\longrightarrow 2K \text{ Sinc } (2f)$

$$\boxed{\text{Signal Bandwidth} = \text{Highest +ve freq.} - \text{Lowest +ve freq.}}$$

$$\boxed{\text{Channel bandwidth} \geq \text{Signal bandwidth.}}$$

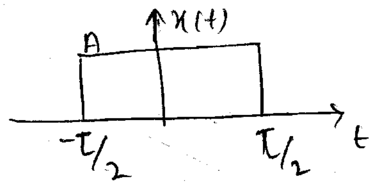
Channel standards -

Co-axial cable - 0 - 600 MHz

Parallel wire - 0 - 200 K

Fiber optic cable - GHz = 10^9 Hz = 1000MHz

- For proper transmission of above signal, channel bandwidth of infinite is required but bandwidth offered by practical channel will be finite only so that before transmission it should be bandlimited by using 'Band Limiting Process'.



$$E = \int_{\infty}^{\infty} x^2(t)\, dt = A^2\tau = \int_{\infty}^{\infty} |X(f)|^2 df$$

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Computer Fundamental

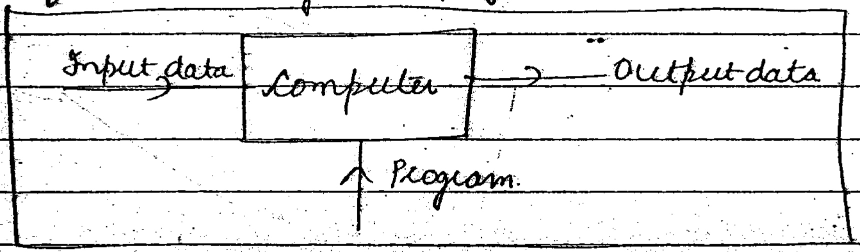
By.Sagar Sir

- Theory
- Explanation
- Derivation
- Example
- Shortcuts
- Previous Years Question With Solution

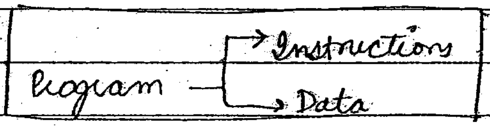
Computer Fundamentals

Keywords :-

Computer → It is a computational machine used to process the data under the control of a program ∴ computer system functionality is program execution.



Program :- Program is a sequence of instructions along with a data.

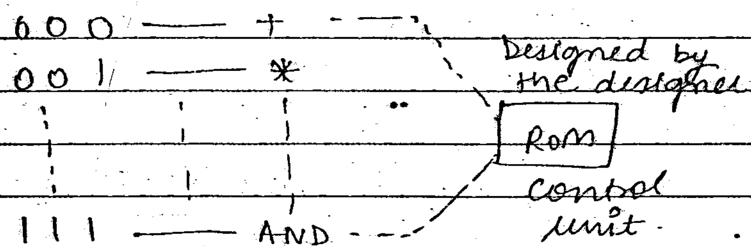


Instruction :- It is a binary code, which is designed inside the processor to perform some task.

Binary code – binds with – operation.

Ex:- CPU-X supports 8 different operations, then
opcode = $\log_2 8 = 3$ bit.

opcode operation



how we are writing the program – is stored in RAM

Q 6 bit Opcode → No. of operations?

$2^6 = \boxed{64}$

Data ⇒ It is a binary code, which is associated with a value based on the data format.

Binary code – bind with – value

Ex- 101 = 5 , −1 , −2 , −3 , fraction

↳ sign magnitude format

$\overset{2\;1\;0}{1\;0\;1}$

4 + 1 = 5

$\underbrace{1}\underbrace{01}$

−1

$\underbrace{1}\underbrace{01}$

$\overset{10}{-2}$ → 1's compliment format

$\underbrace{1}01$

10

$-\frac{1}{11}$ = −3 → 2's compliment format

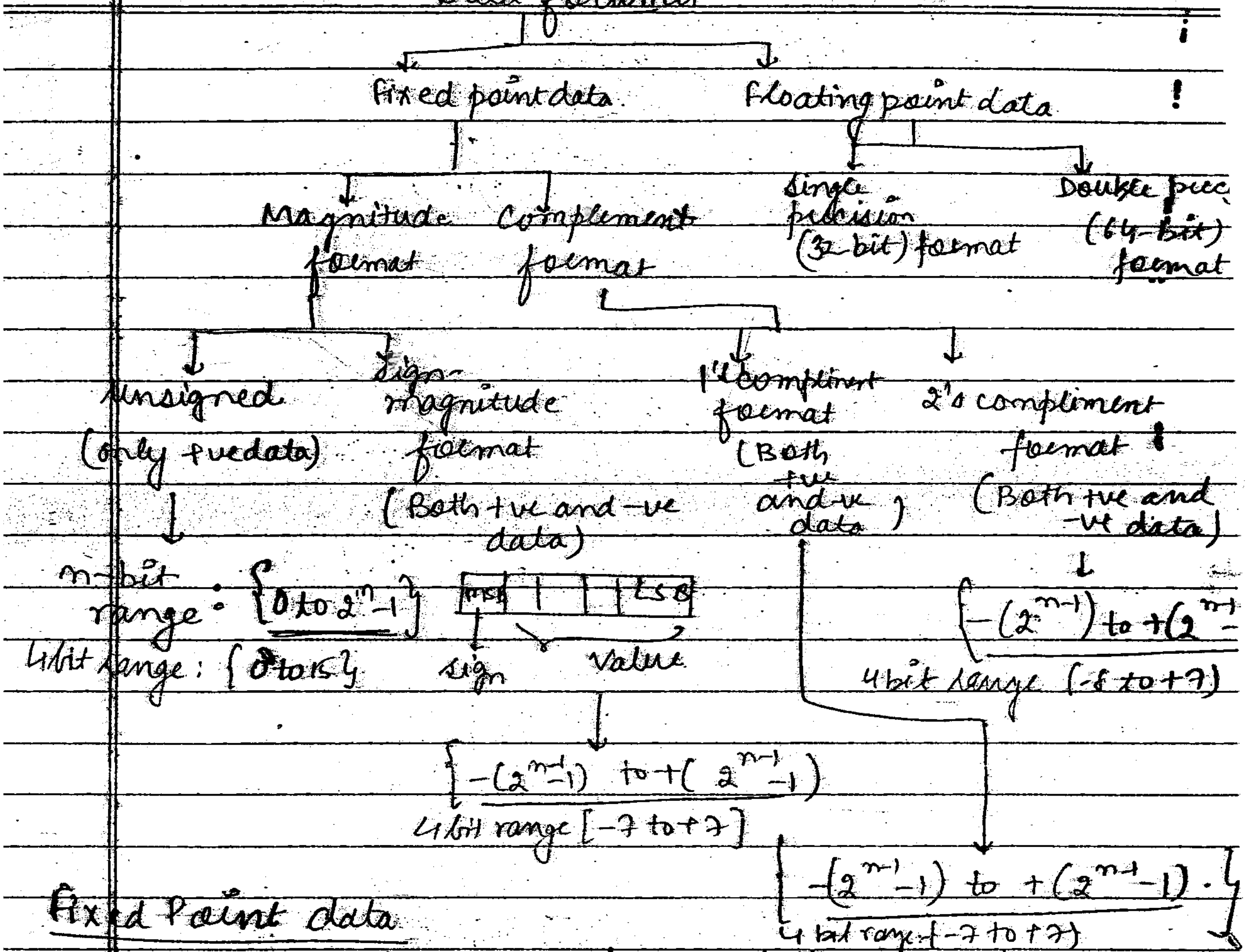
fraction :- floating point format

→ Fixed point data

→ Floating point data

Topic 1: Data Representation

Data formats



Fixed Point data

4-bit binary	unsigned data	sign mag.	1's compliment data	2's compliment data
0000	0	$\boxed{+0}$	$\boxed{+0}$	+0
0001	1	+1	+1	+1
0010	2	+2	+2	+2
0011	3	+3	+3	+3
0100	4	+4	+4	+4
0101	5	+5	+5	+5
0110	6	+6	+6	+6
0111	7	+7	+7	+7
1000	8	$\boxed{-0}$	-7	-8
1001	9	-1	-6	-7
1010	10	-2	-5	-6
1011	11	-3	-4	-5
1100	12	-4	-3	-4

	Unsigned data	Sign mag	1's comp	2's compliment
1101	13	-5	-2	-3
1110	14	-6	-1	-2
1111	15	-7	$\boxed{-0}$	-1
		Not in use	Not in use	

→ In computers, binary data (base-2) – computer use
decimal " (base-10) – user data

→ eg. 8 bit single unit – fixed point data
" " in multiple units – floating point data

→ Sign magnitude format : drawback of data redundancy (so it was just the concept and rejected this format)

0000 → $\boxed{+0}$
!
1000 → $\boxed{-0}$
!
1111 → -7

→ In computer only 1's and 2's compliment are there, not other compliments.

→ same problem of +0 and -0 in 1's compliment format ∴ rejected

→ No data redundancy in 2's compliment format ∴ it was implement.

some 1's complement - 1000 → -7 1001 → -6
111 110

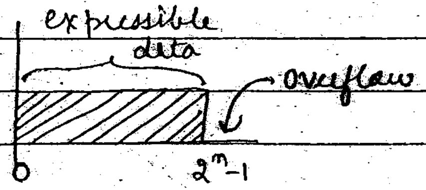
2's complement

1000 → -8 1001 → -7
0111 0110
1 1
1000 0111

Page No.
Date :

Fixed point data → unsigned data (unsigned format)
→ signed data (2's complement format)

Unsigned data



eg. 4-bit range : {0 to 15}

1 1 1
15 : 1111
(+) 15 : 1111
1 30 1110

overflow → 5 bit data (0 to 31)

overflow :- no's out of range of (0 to 15) all are overflow.

Test with 5 bit data : {0 to 31}

n-bit + n-bit = (n+1) bit
↓
1 bit storage space
↓
1-flip flop
↓
flag
↓
carry flag.

→ Multiplication

Multiplicand * Multiplier
1111 * 1111 ← LSB

2 1
3 1 1 1 1
3 1 1 1 1
2 1 1 1 1
1 1 1 1
} partial products.

11100001 } final product

carry
2 → 10
4 → 100 carry
6 → 110 cy
5 → 101 cy

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ELECTRICAL ENGINEERING

Basic Electronics

By.Rajender Sir

Books:-

1) Semiconductor Physics and Devices
— DONALD NEAMEN.

2) GATE
↳ Basics } Solved Examples
↳ Diode } of Donald Neamen.
↳ ** FET

*CLASSIFICATION OF TEMPERATURE (T):-

*Divided into three parts:-

1) ABSOLUTE TEMPERATURE (0K = −273°c)
2) ROOM TEMPERATURE (300K = 27°c)
3) AMBIENT TEMPERATURE (T_A) (290K = 17°c)

old Notation

** $\boxed{°K = K}$

New Notation

* Absolute Temperature is Practically not Possible. It is only the Reference Temperature, and never used in Reality.
* Absolute Temperature is just a Reference temperature
* At Room temperature, all properties of semiconductor Devices are maxm at Room temperature.
* All Properties of commn systems are taken at the Ambient Temp. ie 290K or 17°c.

** * $\boxed{\text{TEMPERATURE in KELVIN} = \text{TEMPERATURE in } °c + 273}$

*THERMAL VOLTAGE (V_T) :-

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

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

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

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

Hence,

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

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

**

$$\boxed{\begin{aligned} V_T &= 0.02568 \text{ volts} \\ &= 26 \text{ mV.} \end{aligned}}$$

Note:

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

* BOLTZMANN CONSTANT:

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

$$K = 8.62 \times 10^{-5} eV/°K$$

**

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

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

**

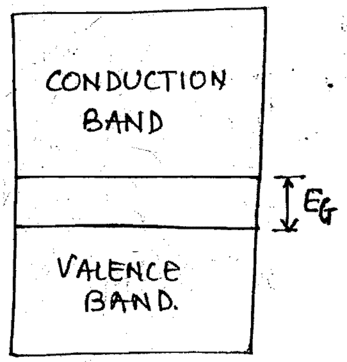
$$\boxed{V_T = KT = \frac{\bar{K}T}{q}}$$

↳ Numerically equal values.

* ENERGY GAP (E_G or E_g):

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

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



→ Forbidden Energy Gap

↳ Band Gap.

*

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

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

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

* To calculate E_G at different temp we can use:

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

β_0 = material constant (eV/°K)

* For Germanium:

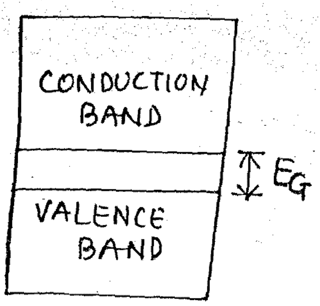
$$\boxed{E_G(T) = 0.782 - 2.33\times10^{-4}\,T \text{ (eV)}}$$

* For Silicon:

$$\boxed{E_G(T) = 1.21 - 3.6\times10^{-4}\,T \text{ (eV)}}$$

* For a semiconductor, Energy Gap is small

↳** $\boxed{E_G \le 1.5\text{eV}}$



Note :

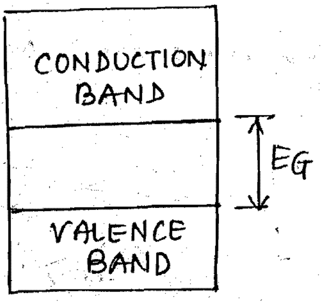
1) Semi Conductors are BIPOLAR
2) Semi Conductor can contribute DIFFUSION CURRENT.
3) Semi Conductor has NTC of RESISTANCE

** $\boxed{T\uparrow \quad R\downarrow}$

*Note:

* For insulators, the Energy Gap is large

↳** $\boxed{E_G \geq 5eV}$



* Insulators are Bad conductors of current, and their Conductivity is negligible.

* For Ideal insulator, Conductivity is zero.

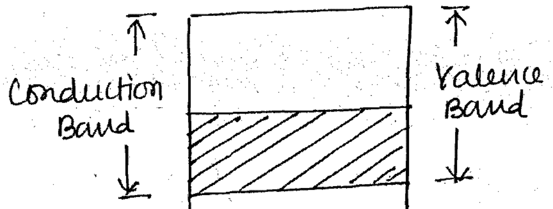
Note:

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

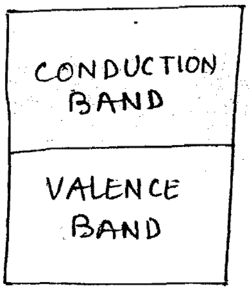
* For Metals (Conductors):

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

↳ (Non Zero Energy Gap)



(at T= 300K)



(at T=0K)

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

* Conductivity is very large in conductors

* Only DRIFT CURRENT flows in conductor

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

* PTC of Resistance:** $\boxed{T\uparrow\ R\uparrow}$ ← Exclusive Property of Metals.

*Definition of Semiconductor :-

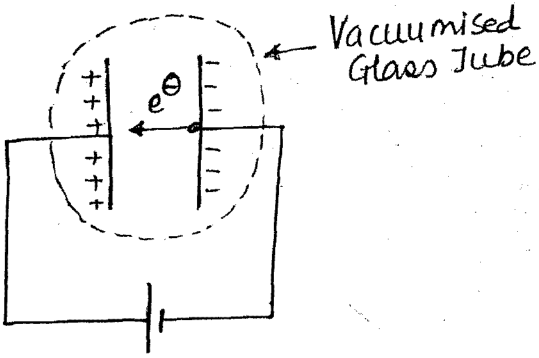
* Semiconductors are the elements whose conductivity lies in between in the conductivity of an insulators and the conductivity of a metal.

* ELECTRON VOLT (eV) :-

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

Note :-

*Air is a perfect insulator, the Best insulator.



Note :-

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

Mathematically,

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

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

$$** \quad = 1.6\times10^{-19} C.V$$

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

Note :-

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

Mathomatically,

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

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

** Potential Energy = $q \times V$

V=Potential difference

By definition:-

KE gained = PE lost

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

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

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

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

* Mathematically,

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

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

Note:-