Notes on

Electronic Measurement and Instrumentation

by

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Error Analysis :

Error :- The deviation of measured quantity from the true value (or) actual value, is called error.

(E)

$$\boxed{E = A_m - A_t}$$

True value (or) Actual value.

measured value

+ve (or) -ve.

Error may be (+ve) or (-ve).

+ve → $A_m > A_t$.

-ve → $A_m < A_t$,

Error classified in to 2 types.

① static Error.

② Dynamic ,,

① **Static Error :-** The error independent which is independent of time.

② **Dynamic Error :-** The error depends on time are called dynamic error.

Correction factor [C.F] :- The value which we are added (or) subtracted from the measured quantity in order to get true value is called correction factor.

C.F. may be +ve (or) -ve.

$\boxed{C.F. = -(\varepsilon)}$ If ε = +ve, C.F. = -ve

ε = -ve, C.F = +ve

Relative static Error :-

The error taken over the true value.

$$R.S.E. = \frac{\varepsilon}{A_t} = \frac{A_m - A_t}{A_t}$$

$$\boxed{\% R.S.E. = \frac{A_m - A_t}{A_t} \times 100}$$

↓

It determines the quality of instrument.

A	B
$A_t = 2A$	$A_t = 1000A$
$\varepsilon = 1A$	$\varepsilon = 10A$
% R.S.E $= \frac{1}{2} \times 100$ $= 50\%$	% R.S.E. $= \frac{10}{1000} \times 100$ $= 1\%$

Limiting Error :- It is specified by the manufacturer. It will give the range of operⁿ. It is always w.r.t. true value. The other name is Tolerence and uncertainty.

0-10 Amp	% L.E.
company A →	± 2%
" B →	± 1%
" C →	± 0.5% → choose
" D →	± 0.0% → not choose.

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For A :- $2 \times \frac{\pm 2}{100} = \pm 0.04$

2 ± 0.04

2.04

1.96

Similarly for C :-

$2 \times \frac{\pm 0.05}{100}$

$= \pm 0.01$

(2 ± 0.01)

1.99 2.01

Let 2A is true value, then Limiting error gives the range of operation.

$$= \frac{9\ \text{volt}}{1\ \text{mA}} = \boxed{9K\Omega}$$

$$\begin{tikzcd} 1mA,\ 100\Omega \arrow[r, "0.9K\Omega"] \arrow[rr, bend right, "9.9K\Omega"'] & 1\ \text{volt} \arrow[r, "9K\Omega"] & 10\ \text{volt} \end{tikzcd}$$

ELECTRICAL MEASUREMENT :-

Que:- A (0-10) Amp with % L.E. = ±1%. If we measure a true value of 2 Amp with this meter. Then the range of error is ___ .

Soln:- $2 \times \frac{\pm 1}{100} = \boxed{\pm 0.02}$ measuring 2 is

range of error $(2 \pm 0.02) = \boxed{1.98 \text{ to } 2.02}$

0-10 is full scale value.

True value $(A_t) = 2$

measured value (A_m) is $\underbrace{(1.98 \text{ to } 2.02)}_{A_m}$

$A_m - A_t = \in$ (Error).

Basic characteristics of an instruments:

A ⇒ Accuracy

P ⇒ precision

L ⇒ Linearity

S ⇒ sensitivity

D ⇒ Dead Time.

D ⇒ Dead Zone.

R ⇒ Resolution.

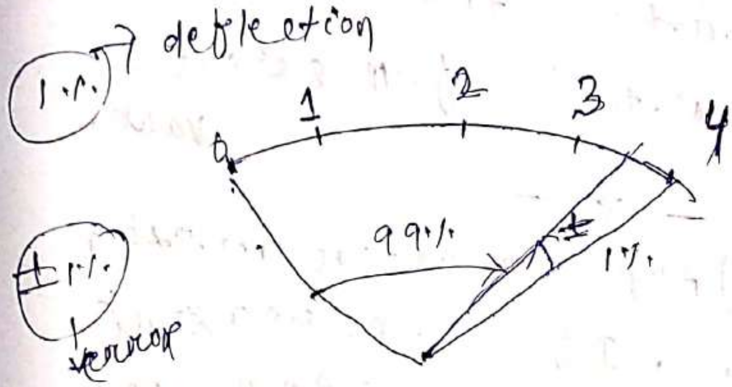
Accuracy:- It indicates the degree of closeness of measured quantity to true value.

Instruments	Accuracy
↑ A	±1%
B	±99%
↑ C	98%
D	1%

↑ Best instrument

when ± symbol is there we will see ~~[illegible]~~ its minimum value.

when ± is not available we will see the highest value.



Backward ±1%

forward 99%

Guaranteed Accuracy Error (G.A.E.):- It is specified by the manufacturer. It is a constant error seen by the instrument. Since the G.A.E. is w.r.t. fullscale value.

ex:- (0–$\boxed{10}$) Amp ; % G.A.E. = $\boxed{\pm 1\%}$

Range

↓

$10 \times \pm\frac{1}{100} = \boxed{\pm 0.1}$

% L.E.

1 Amp ± 0.1 $\longrightarrow 1\times\frac{x}{100} = 0.1 \Rightarrow x = 10\%$

2A ± 0.1 $\longrightarrow 2\times\frac{x}{100} = 0.1 \Rightarrow x = 5\%$

5A ± 0.1 $\longrightarrow 5\times\frac{x}{100} = 0.1 \Rightarrow x = 2\%$

9A ± 0.1 $\longrightarrow 9\times\frac{x}{100} = 0.1 \Rightarrow x = 1.1\%$

L.E. charged

G.A.E. constant B.C.Z full scale constant

↳ As the pointer reaches to fullscale value the % L.E. decreases but the ~~guaran~~ G.A.E. constant. since true value. But

% L.E. of w.r.t. full scale value.

% G.A.E. of w.r.t.

—x—

Ques:- A (0–10) Amp ammeter contra G.A.E. ± 1%. If we measure a true value of 2.5 Amp then the % L.E. is ___.

Soln:- (0–10) Amp   % G.A.E. = ±1%

$$10 \times \frac{\pm 1}{100} = \pm 0.1$$

$$2.5 \pm 0.1$$

$$\Rightarrow 2.5 \times \frac{x}{100} = 0.1$$

$$\Rightarrow \boxed{x = \pm 4\%}$$

—x—

Que:- A (0-100 volt) voltmeter with a G.A.E. of 98% . If we measure a true value of 25 volt with this meter. Then % of L.E. is —.

Solⁿ:- $(0-100V) \longrightarrow 98\%$
(or) $\pm 2\%$

$A_t = 25V$ $\qquad 100 \times \frac{\pm 2}{100} = ② L$

25 ± 2

$\Rightarrow 25 \times \frac{x}{100} = 2 \Rightarrow \boxed{x = \pm 8\%}$

— x —

Que:- A 0 to 20 Amp ammeter with a G.A.E. ±1% of reading. If we measure a true value of 2.5Amp. Then the % L.E. = ?

Solⁿ:- Reading = 2.5 Amp

G.A.E. of reading = ±1%

so L.E. w.r.t. true value is $= \boxed{\pm 1\%}$

— x —

Precision:- The most Repeatable value (or) reproducable value out of set of ~~records~~ records is known as precision.

$A_t = 2A$

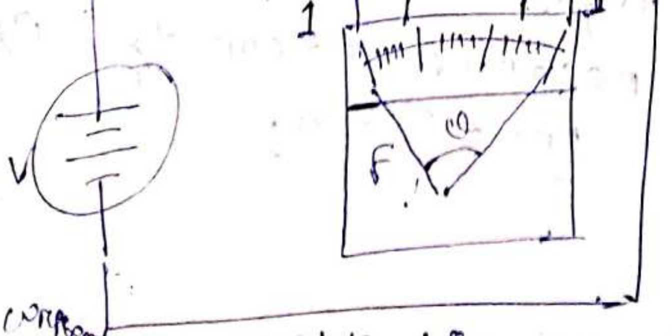
A	B
1.9 ✓	1.9
1.9 ✓	1.5 ✓
1.5	1.5 ✓
1.9 ✓	1.5 ✓
1.5	1.9
1.9 ✓	1.5

Accurate and precise → Best instrument

precise → worst instrument

The accurate instrument maybe precise. But precise will not conform any accuracy. Be prefer always accurate ~~and~~ as well as precise instruments.

Linearity :- The o/p follows the i/p with the linear rel^n (or) linear eq^n is called linearity.



I, is measurable quantity in every meter. Inside the circuitary.

I = is current (i/p)

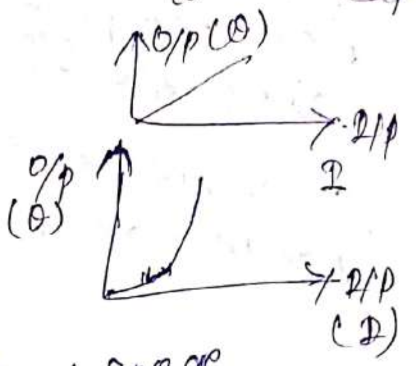
θ = Deflection angle (o/p)

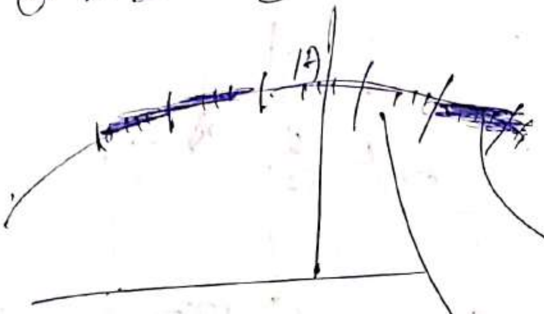
F = Force

1-7 All meters are ~~con~~ ~~con~~ energy conversion device. Electrical $\xrightarrow{\text{to}}$ mechanical

$\theta \propto I$ [Linear]

$\theta \propto I^2$ [Non Linear]





Df At = 17 Amp

① (0-100) A (✗)

② (0-20) A (✗)

③ (0-30) A ——— It is the best instrument due to entering in Linear Region.

we have to select always the meters in such a way that the pointer should enter in to linear region. so we may not loose accuracy.

Sensitivity (S)

$$S = \frac{\text{change in o/p}}{\text{unit change in } \cancel{o/p}\ i/p}$$

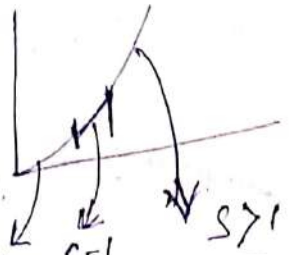
It is the ratio of change in o/p to the unit change in i/p. we prefer always high sensitive instruments. So that we may not loose accuracy.

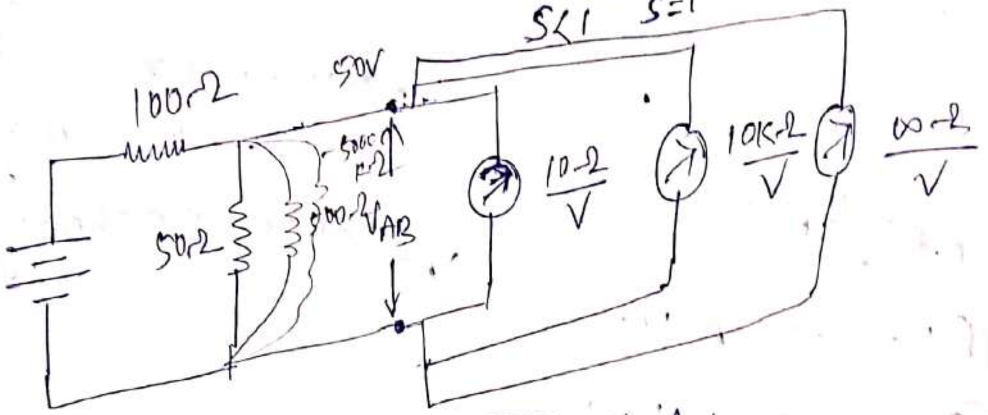
so $\boxed{S = \frac{\Delta o/p}{\Delta i/p}}$ = Slope of input/output characteristics is called sensitivity.

$\Rightarrow \boxed{S = \tan\theta}$

For perfect linear instrument the sensitivity is constant throughout the scale. $S = \tan 45^\circ = \boxed{1}$

S is not constant in non linear region.





$150 \times \frac{50}{150} = \boxed{50V} = At$

~~150~~ $S = \frac{10\Omega}{V}$ $\quad$ 1 volt = 10Ω
$\quad$ 50 " = 500Ω

$500 \| 50 = 45.45$

$\Rightarrow 150 \times \frac{45.45}{145.45} = \boxed{46.87}$ volt

$\frac{10K\Omega}{V} \Rightarrow$ 50volt = 5000KΩ

$50 \| 5000K\Omega = 49.999$

$\Rightarrow V_m = \frac{150 \times 49.999}{149.999} = 49.9991$

If $\boxed{\frac{\infty\Omega}{V} = S}$, then $\boxed{V_m = V_t}$

So the error can be minimized.

— x —

$S = \Omega / V$ [for ~~for~~ voltmeter]

venugopal eee

$\frac{1}{(V/\Omega)} = \boxed{\frac{1}{I_{FSD}}}$

fullscale defleetion current.

Que: A 0 to 10 volt voltmeter with a sensitivity of $20 \frac{K\Omega}{V}$. Then find the allowable current through ~~the~~ meter at half full scale reading.

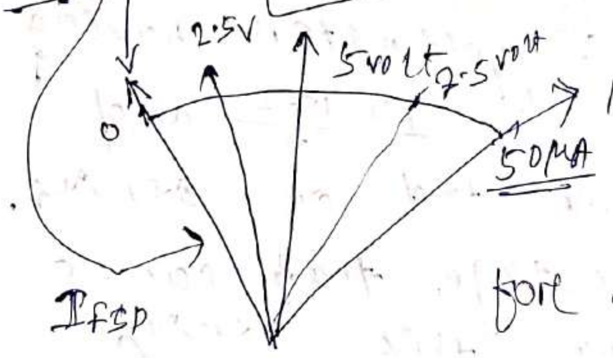
Soln: $S = \frac{1}{I_{FSD}} \Rightarrow I_{FSD} = \frac{1}{S}$

$= \frac{1}{20 \frac{K\Omega}{V}}$

$= \boxed{50 MA}$

$I_{FSD} = 50MA$

$\boxed{25 MA}$



I_{FSD}

$\frac{I_{FSD}}{2}$

for 2.5volt $I = \frac{25MA}{2}$

$= \boxed{12.5 MA}$

for 7.5volt $= 25 + 12.5$

$= \boxed{37.5MA}$

ELECTRONIC MEASUREMENT:-

DC Volt meter:-

Que: A DC voltmeter with a figure of merit of $20 \frac{K\Omega}{V}$ is used to measure half full scale voltage in 10V DC range. Then the current through the meter is —.

Instrument and meter:-

Instrument is a part of meter.

Instrument can be made different meters i.e. Ammeter and voltmeter.

Instruments: It has no application.

But when we use Instrument as diff. meters then the meters can measure different ~~values~~ measuring quantities.

↳ Ammeter can be used in series.
voltmeter " " " " parallel.

↳ If voltmeter is used as ammeter the current will not go through the voltmeter. (nothing happen.)

↳ But if ammeter is by mistake used as voltmeter then high current will be ~~ha~~ pass and it ammeter will be damaged.

↳ If voltmeter range increase (0, 10V, 20V, 30V, ...) the series Resistance increase.

↳ If Ammeter range increase (0, 10A, 20A, 30A, ...) the shunt resistance decreases.

voltmeter:- A high resistance is in series with ~~[illegible]~~ instrument is called. voltmeter.

Ammeter: ~~conclusion~~: By connecting low resistance ~~co~~ across (or) parallel to the instrument is called Ammeter.

→ The value of $\boxed{R_{sh} = \frac{R_m}{\left(\frac{I}{I_m}\right) - 1}}$.

→ The value of $R_{se} = R_m(m - 1)$ (or)

$$= R_m\left(\frac{V}{V_m} - 1\right)$$

m = multiplication factor.

→ For higher value of current the internal resistance ~~rest~~ will be decrease. For a higher value of voltage Rse value increase.

→ Ammeter we have to connect always in series in the ckt, since inside ammeter parallel ckt is there so that current will be divide instrument will be safe.

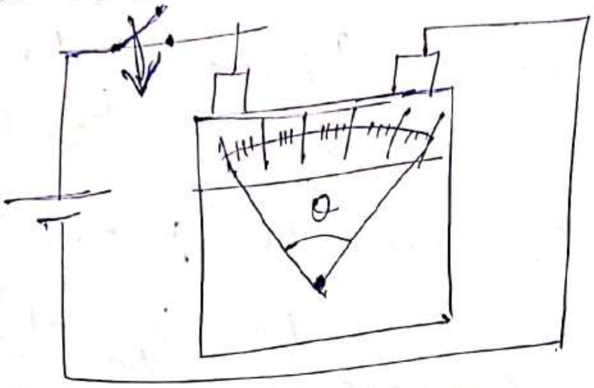
→ voltmeter we have to connect in parallel, since inside the ckt is the voltmeter series ckt will be there. So that voltage will be divided instrument will be safe.

↳ In Both ammeter and volt-meter the responsible quantity is current.

↳ The instrument is a part of meter.

—— X ——

Dead Time :-



$\theta \propto I$

$\theta \propto I \propto V$

$\boxed{\theta \propto V}$

In all electrical instruments the responsible quantity is current.

In case of current measurement

θ ~~I~~ $\propto I$.

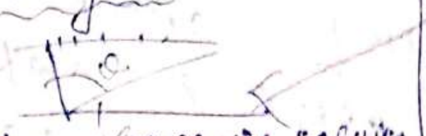
↳ In case of voltage measurement.

$\theta \propto I$, $I \propto V$

~~$\theta \propto V$~~

$\Rightarrow \boxed{\theta \propto V}$

NOTE :- In all electronic instrument the responsible quantity is voltage.



for deflection force is require
for provide the force current is required
so electrical energy is converted into mechanical energy.

scale is there means electrical instrument
digital display is there means electronic instrument.

All electrical instruments are energy converters. But electronic instruments are not energy converters. Electronic instruments are fast response instruments as compare to electrical " since there is no energy conversion.

→ In all electronic instrument voltage pulses are entering. [counter will ~~[illegible]~~ there be for provide the o/p.]

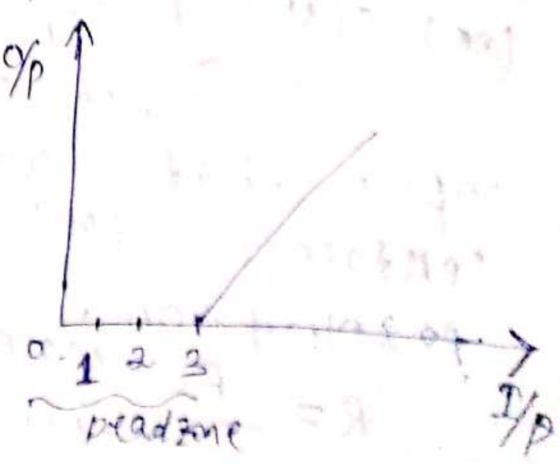
The time taken by the instrument to move the pointer from its initial position is called dead time. In electrical instrument deadtime is more.

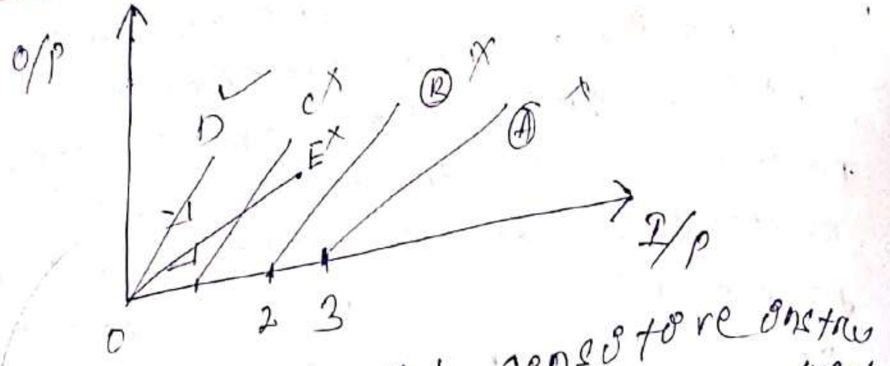
Dead time can not be eliminated but reducible by ~~using~~ making the pointer with very light material (aluminium).

The main reason for dead time is inertia. All the instruments will experience both the transient as well as steady state. Initially transient finally reaches to steady system.

Dead zone :-

It is the minimum i/p ~~where~~ beyond which ~~of~~ the response will come. is called dead zone. (or) Threshold.

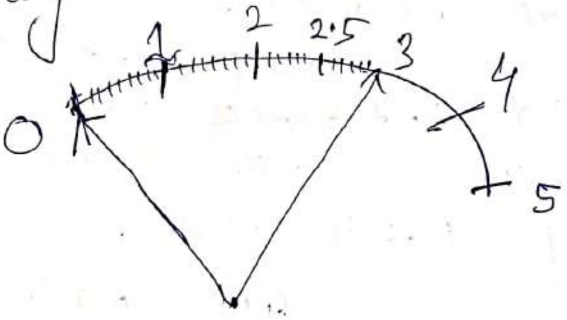




D is ~~hsh~~ high sensitive instrument.

so D is the best instrument.

Resolution :- (R) :— we prefer always high Resolution instruments. As the resolution is more the clarity is more so that we may not 100se accuracy.



The smallest o/p that we can detect in the scale with certainity (or) clarity is called Resolution

(or)

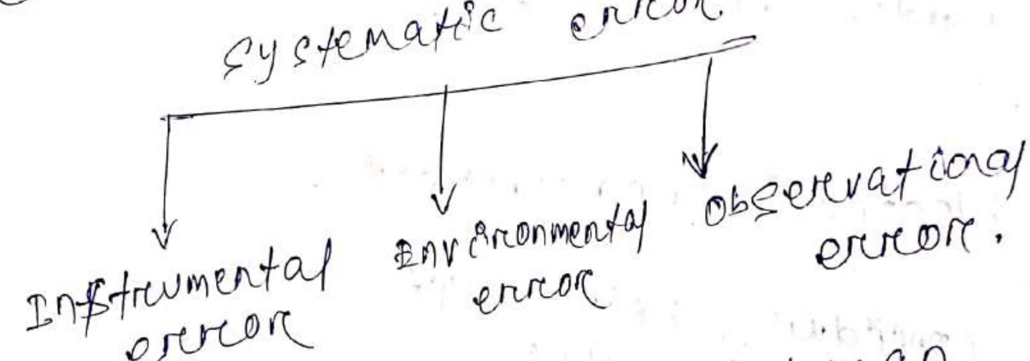
The smallest change in input that we can detect with certainity (or) clarity is called Resolution.

$$R = \frac{\text{Full scale value}}{\text{Total no. of divisions}}$$

Here If No. of Divisions increases, our resolution also increases.

TYPES OF ERRORS :-

1. Gross error.
2. Systematic ,, ,
3. Random ,, .



① **Gross Error :-** All the human negligence errors by taking the readings (or) whole operating the calculatings are comes under Gross error.

↳ It is not common to all human beings.

Instrumental errors :- Error due to instruments problems.

Environmental Error :- Any error comes due to environment condⁿ.

Observational Error :- (or) parallax error. It is common to all human beings.

Random error :- There is no particular reason for error. It occurs randomly.

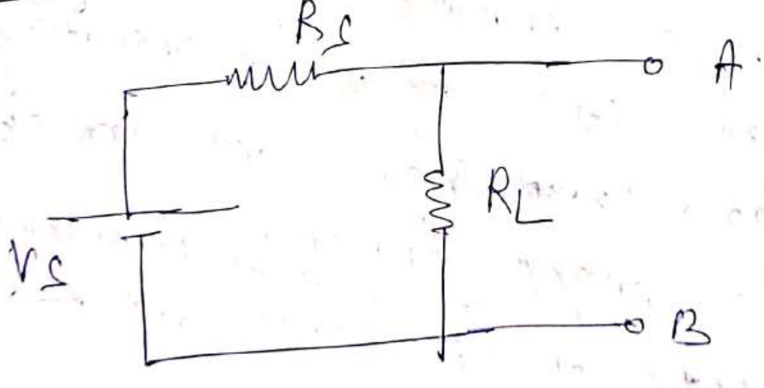
The Random errors may be ~~#~~ (+ve) may be (-ve). All the instruments may offer Random errors. Random errors can be solved by using mathematical tool statistics. like Arithmatic mean, mode, and standard deviation.

Random error Analysis:-

Electronic measurement:-

consider below ckt.

True ckt. condns:-



R_L (true) $= R_L || \infty$

$= R_L$

V_L (true) $=$ 'V' across R_L

$= V_S \times \frac{R_L}{R_S + R_L}$

= True (or) Actual voltage.

Electrical measurements :-

Random error Analysis :-

(0-150) volt $A_t = 100$ V

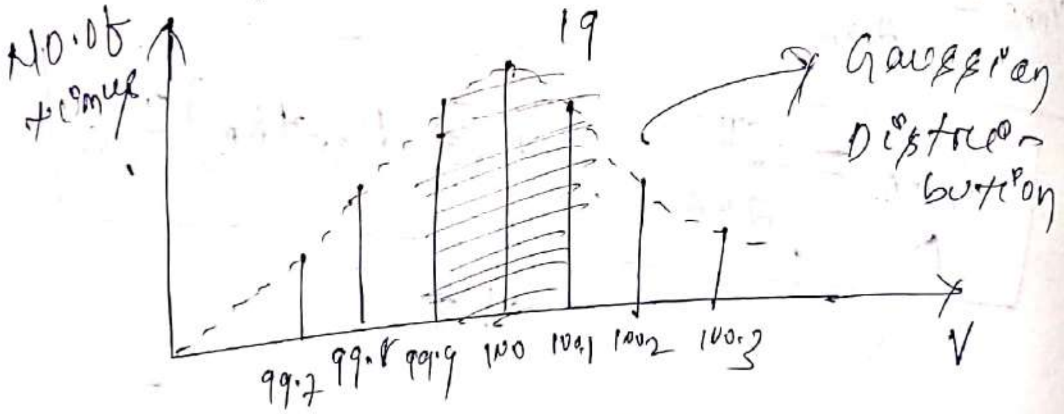
50 times

99.7 volt → 1
99.8 volt → 4
99.9 " → 12
100 volt → 19
100.1 volt → 10
100.2 volt → 3
100.3 volt → 1

50

−0.1
+0.1
±0.1
±0.2

22 times



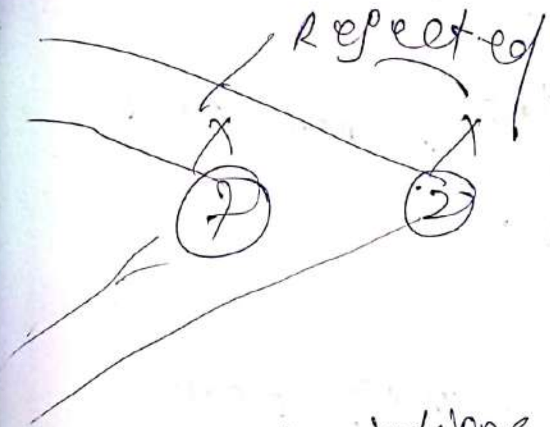
probable Error = ±RC
$$= \boxed{\pm 0.6745\sigma}$$

σ = standard Deviation

$$= \sqrt{\frac{d_1^2 + d_2^2 + \cdots + d_n^2}{(n-1)}}$$

If n≤2

If n>20 then (n)



Small deviations are more probable compare to Large deviations.

NOTE:- In case of addition and subtraction, the absolute errors will be added up.

Let $R_1 = (100 \pm 4)\ \Omega$ $\quad R_1 + R_2 = (150 \pm 6)\ \Omega$

$R_2 = (50 \pm 2)\ \Omega$ $\quad R_1 - R_2 = (50 \pm 6)\ \Omega$

NOTE:- ② In case of multiplication and division the percentage errors will be added up.

$R_1 = 50 \pm 6\%$ $\quad R_1 \times R_2 = 5000 \pm 9\%$

$R_2 = 100 \pm 3\%$ $\quad R_1 / R_2 = 5 \pm 9\%$

$$R_1^2 \cdot R_2 = 5000 \pm 2 \times 3\% + 1 \times 6\%$$
$$= 5000 \pm 6\% + 6\%$$
$$= \boxed{5000 \pm 12\%}$$

Que:- which of the following meters requires an external power source for its operation.

(a) PMMC meter.

(b) Heart wire ".

[✓ (c) ~~EMV~~ EVM meter.]

(d) EDM.

—x—

Que:- which of the following device is used at the 1st stage of an electronic voltmeter.

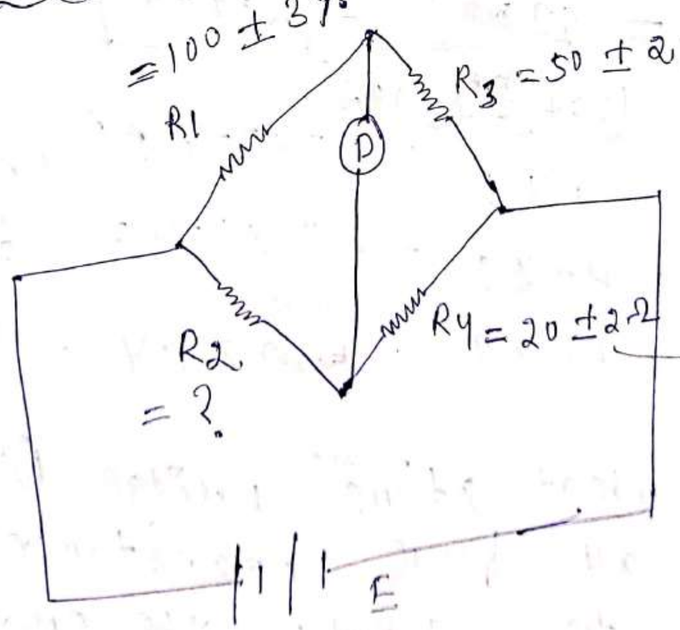
(a) BJT. (b) SCR [✓ (c) MOSFET.]

(d) UJT.

↓ Bcz High input resistance.

—x—

Electrical Measurements :-



20%

→ $20 \times \frac{x}{100} = 2$

⇒ x = 10%

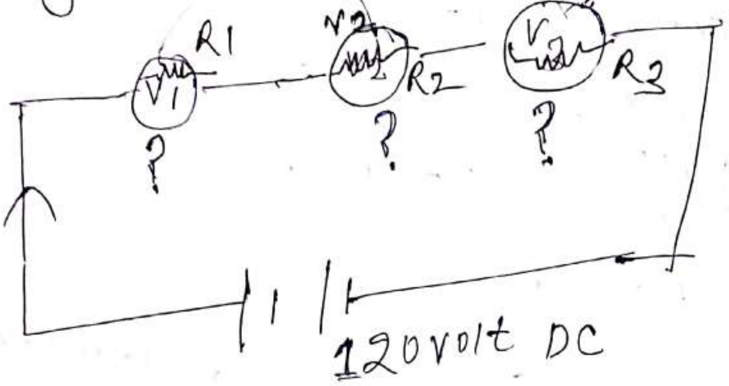
3% + 2% + 10%

= $\boxed{15\%}$

Sol:- $R_2 = \frac{R_1 \cdot R_4}{R_3} = \frac{100 \times 20}{50}$

$= 40 \pm 15\%$

Que: 3 voltmeters are connected in series across 120 volt dc supply. The voltmeters are ① $v_1 = 100$ and 5 mAmp. ② 100V and 250 Ω/V ③ 100mA and 5KΩ.



Then estimate the each voltmeter reading.

Soln:

$$R_1 = 100/5mA = 20\,K\Omega$$

$$R_2 = 100V \times 250\Omega/V$$

$$= 25K\Omega$$

$$I = \frac{120}{(20+25+5)K\Omega} = \boxed{2.4\,mA}$$

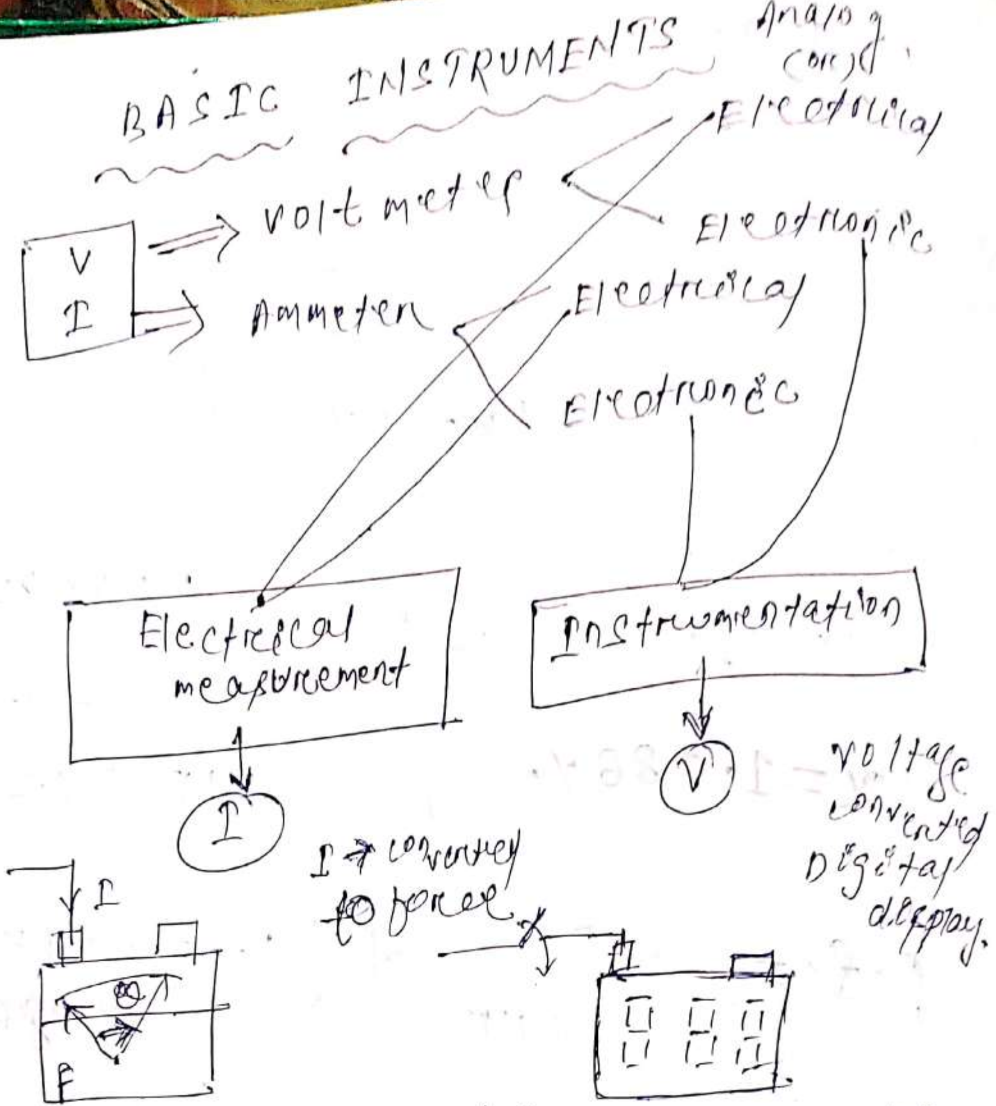
$$V_1 = R_1 \times I = 20 \times 2.4\,mA = 48V$$

$$V_2 = R_2 \times I = 25 \times 2.4 = 60V$$

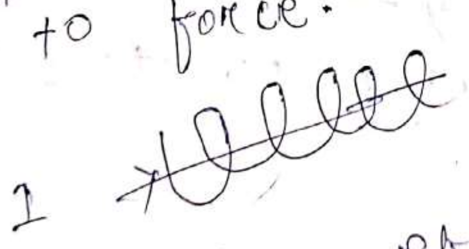
$$V_3 = R_3 \times I = \overset{5K}{} \times 2.4 = 12\,V$$

Que: A wheat stone bridge is balanced with all four Resistances equal to 1 KΩ. The bridge supply voltage is 100 V. The value of one of the resistances is change to 1010 Ω.

BASIC INSTRUMENTS



Electrical Measurement :- In all electrical instruments the responsible quantity is current. It is converted is in to force.



Ⓘ ↓ Due to current following effects are available.

① magnetic effect → It is used for providing force.
② Thermal ,, .
③ Electrostatic ,, .
④ Induction ,, .
:
⑳ effects available.

Basically there are 3 forces will be developed in electrical instruments
They are ① Deflection force
(or) Torque (Td)

② control force (Tc)
(or) Torque.

③ Damping force.

① Deflection Force(or) Torque
(Td) :-

It is the force required to move the pointer ~~to~~ from its initial position by using any of its effect is called Deflection Torque. But bcz. of this force the pointer will rotate which continuously is undesirable. we required proportional o/p to the i/p, for that we need one more force in the meter which is opposite in dirn to the deflection torque, is called control Torque.

② control Force :- It is the force which is opposite in direction

to the deflection torque.
when $\boxed{T_d = T_c}$ the pointer will come to steady state.

But before coming to the steady state the pointer will make so many oscillation again which is undesirable. we need one more force inside the meter to reduce the no. of oscillation is called Damping force.

Damping force :- It is the force required to reduce the no. of oscillation at the steady state.

controlling Torque is responsible to stop the pointer at various levels. when the i/p is removed is responsible for taking the pointer again to initial position.
Tc

Fun^n of Tc :-

① It will provide a proportional o/p to i/p.
② when the i/p has been removed the pointer should come

back to initial position.

↳ Damping force and Tc is created due to ~~pe~~ Td in opposite direction of Td.

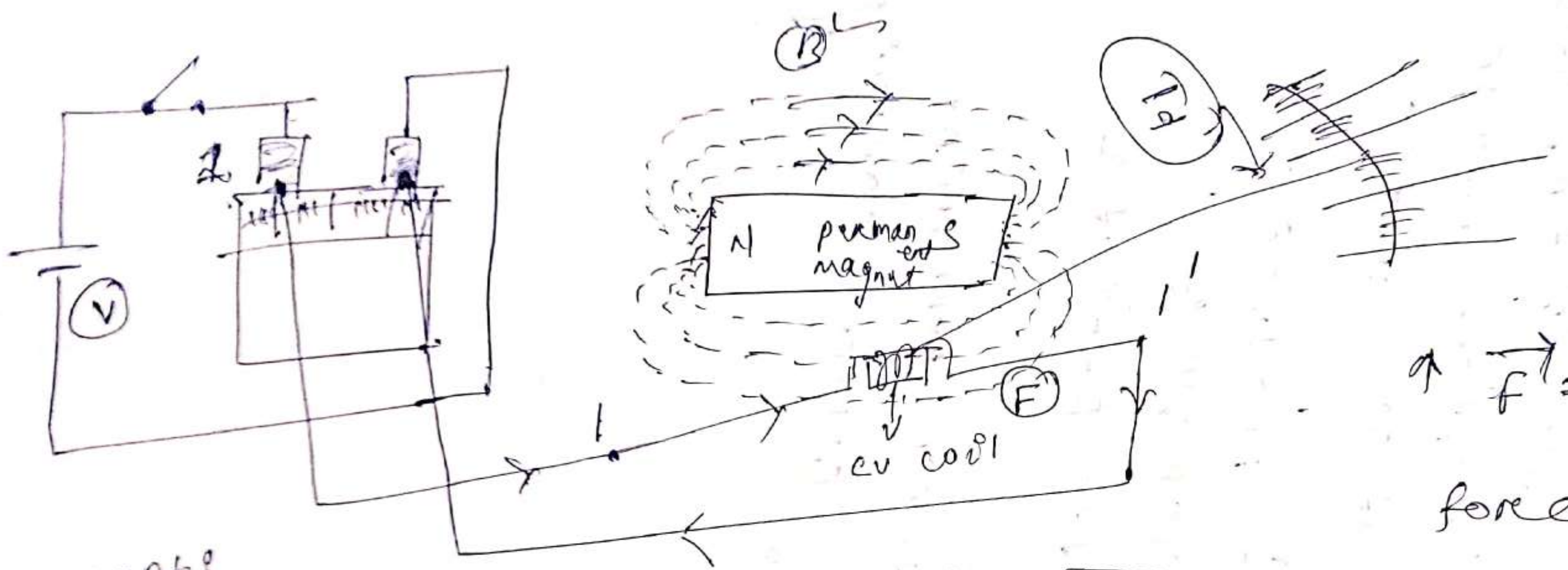
Damping force :- It make to reduce the speed of the pointer. So that the no. of oscillations will be reduced at steady state.

Mechanism for producing Deflection Torque :-

By using magnetic Effect :-

Types :-

(a) Force between permanent magnet and current carrying coil. :-



Lorent'z force Eqn

$$\vec{F} = BIl\sin\theta$$

force ↑ ⇒ I ↑

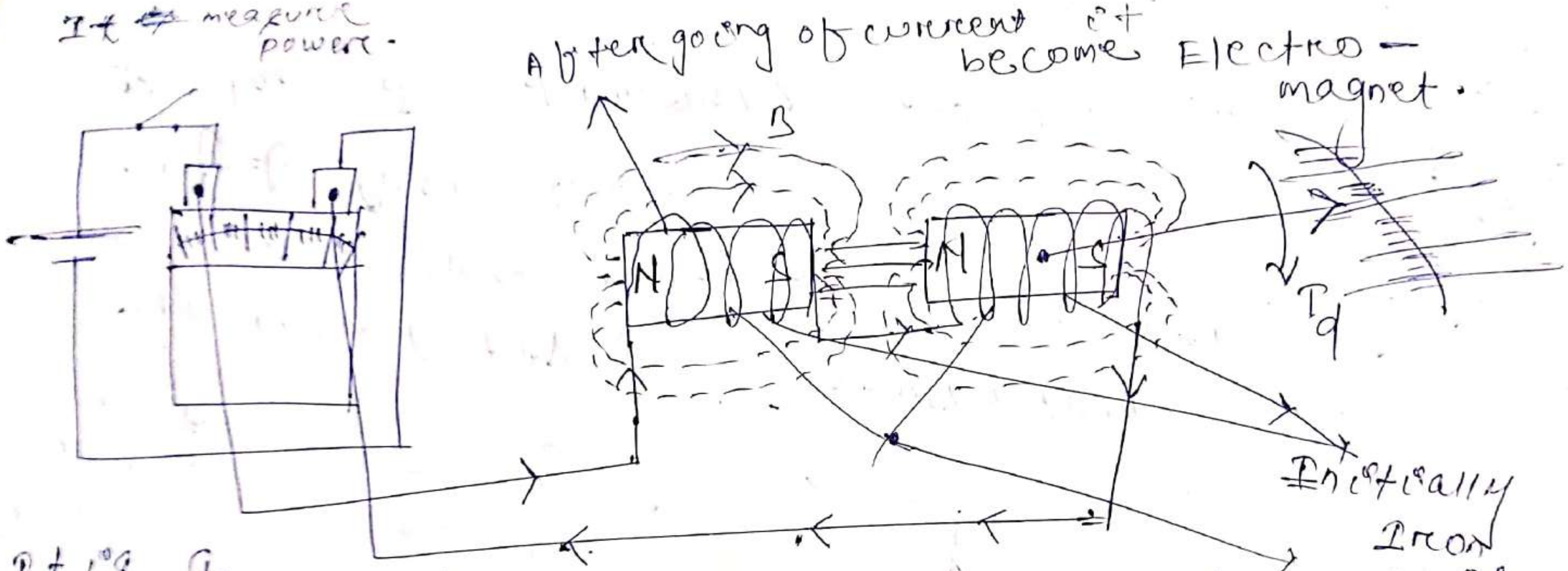
It is PMMC

It canbe measuring only DC

It has 2 terminal out side the box.

(b) ~~force~~ Between two current carrying coils :-

It ~~=~~ measure power.



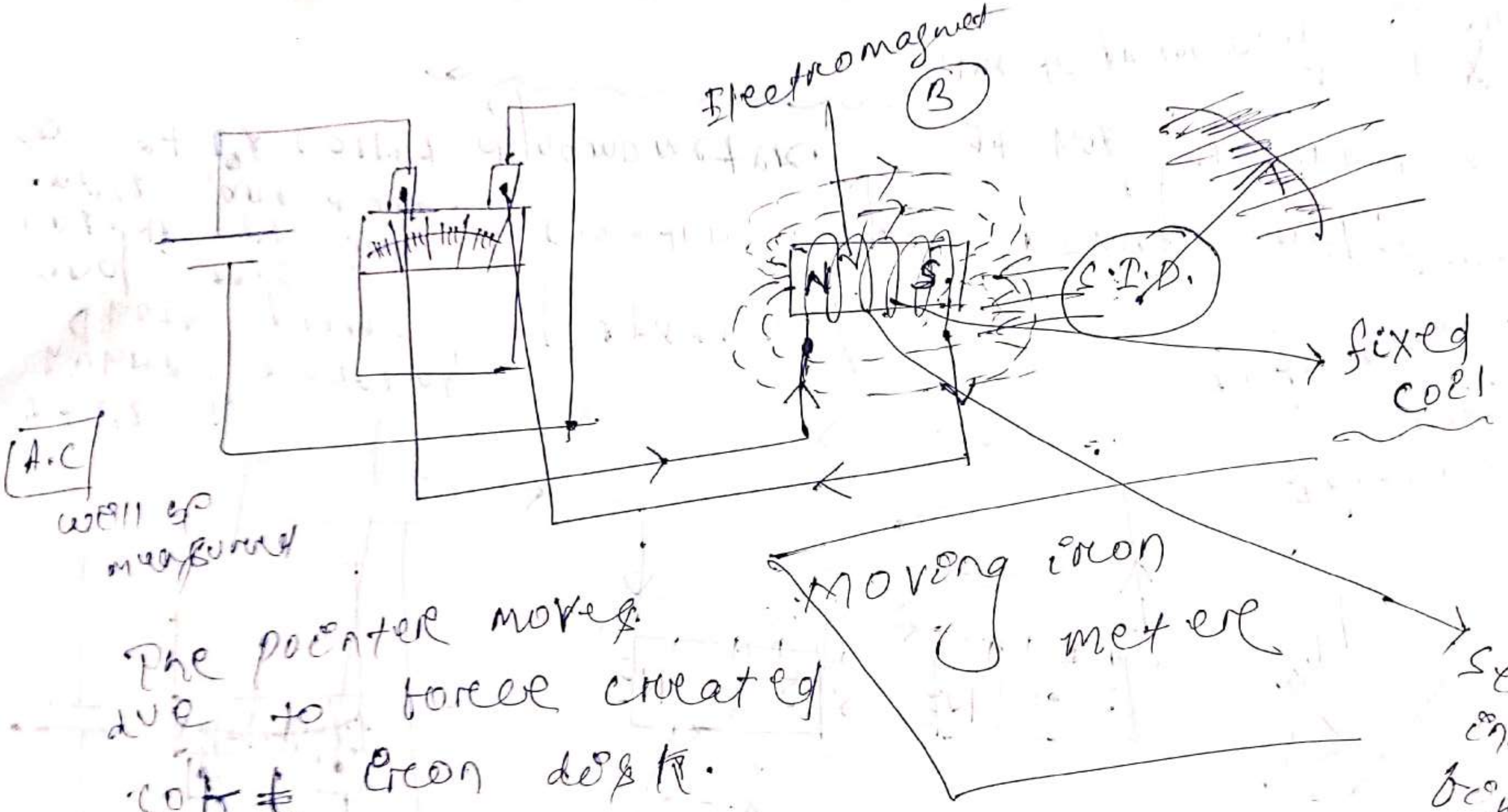
mutual inductance, parameter.

It is a hybred model of both PMMC and M.I Inside it two coils are there. So it is called dynamometer.

EMMC :- Electro magnet moving coil.

It has 4 terminals out side the box due to presence of 2 coils.

ⓒ force betⁿ current carrying coil and soft Iron Disk :-



The pointer moves due to force created soft iron disk.

It has 2 terminals outside the box.

The Resulting difference between the measured and true Q is error in Q-measurement.

Error = $Q_{meas} - Q_{True}$

% Error = $\frac{Q_{meas} - Q_{true}}{Q_{true}} \times 100\%$.

↳ This error in Q-measurement is due to 2 error sources.

① Insertion Resistance (r)

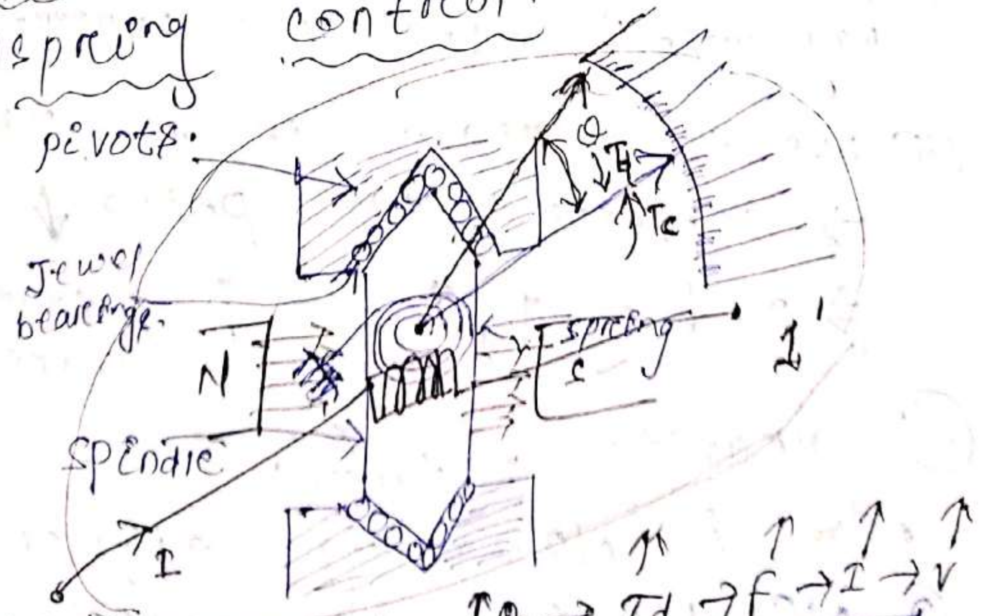
② C_d

↳ The Q-voltmeter is also known as ckt-Q meter.

ELECTRICAL MEASUREMENT :-

mechanism for producing control Force :- (T_c) :-

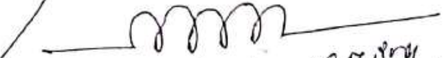
① spring control.



$\uparrow\theta \rightarrow \uparrow T_d \rightarrow \uparrow f \rightarrow \uparrow I \rightarrow \uparrow V$

$\boxed{\theta \propto T_d,\ T_c \propto \theta}$

Spring 2 types.
① spherical spring ② Helical spring.



Helical spring.

↓ generally we use spherical spring.
↓
"phospore Bronze"
↓ ~~mat~~ These materials are used to made spring.

$$\boxed{T_c = K_c \cdot \theta}$$

K_c = spring constant.

K_c unit: $K_c = \frac{T_c}{\theta} = \frac{N \cdot m}{degree}$ (or)
$= \frac{N \cdot m}{Radian}$

Advantages:-

① Lineare Reln. $[T_c \propto \theta]$

② The spring control instruments we ~~can~~ can use in both horizontally and vertically.

Disadvantage:-

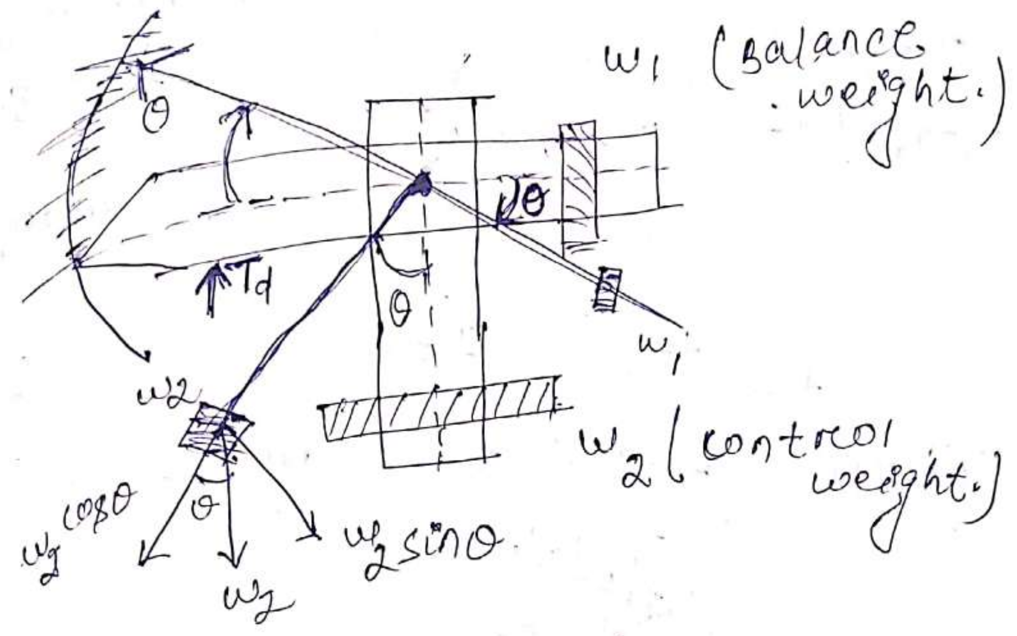
① As the age passes the springs may loose elasticity property.

(ii) Due to increase in temperature
⇒ stiffness of spring ↓
⇒ T_c ↓ ⇒ T_d ↑ ⇒ θ ↑ ⇒ Reading increases.

② Gravity control:-

Adv:- ① No ageing effect.

② NO temperature error.



$\uparrow V \propto \uparrow I \propto \uparrow T_d$

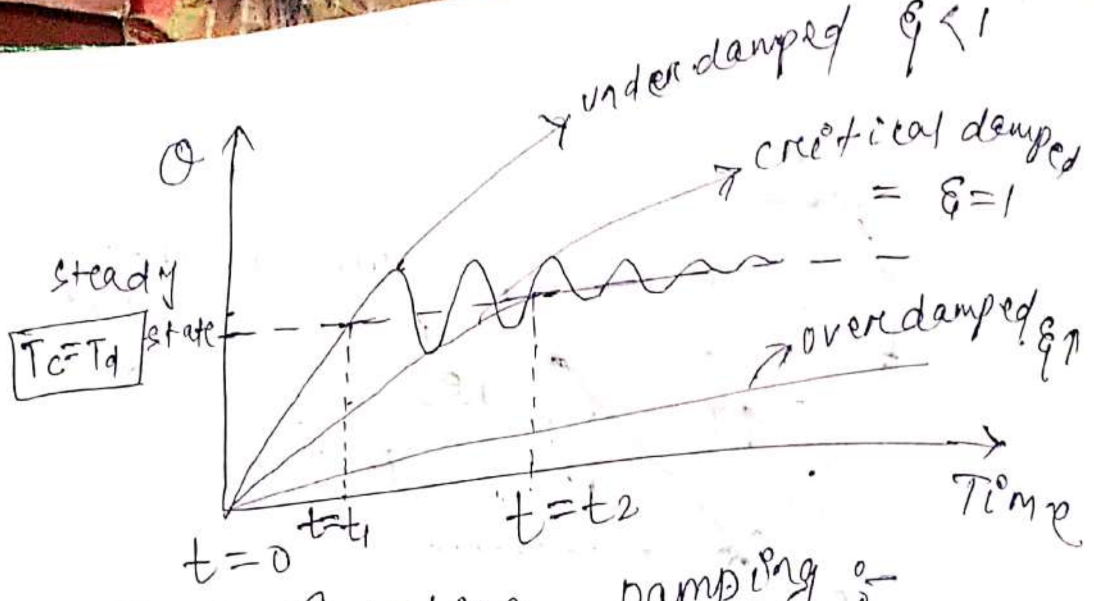
Here $\boxed{T_C \propto \sin\theta}$

Drawback: (i) Non Linear Rel'ship.
(ii) This instrument can be used only in vertical mode. not in horizontal Rel'n.

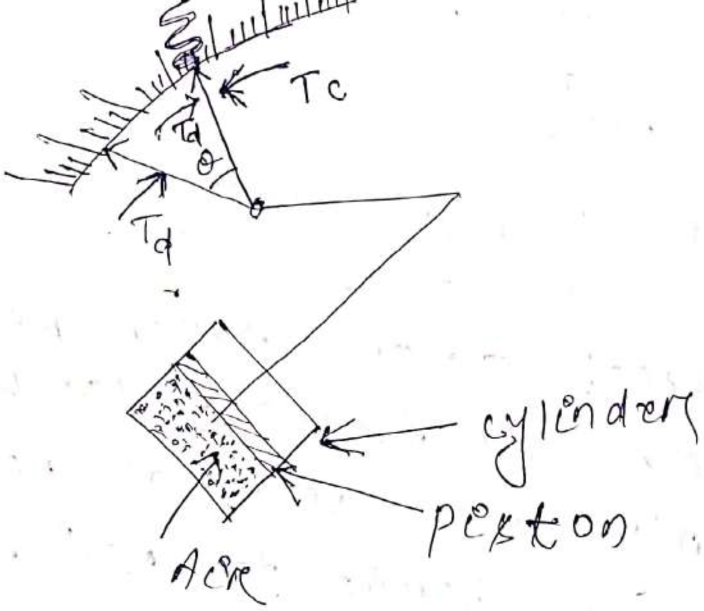
Mechanism for producing Damping Force:

based on speed control we have 3 types of dampings.

generally we use "A little bit less than under damping system.



① Air friction Damping :-



② fluid friction Damping :-

~~Just~~ Replace fluid instead of Air.

fluid damping is more effective ~~accurate~~ ~~reading~~ damping compare to air friction damping. Since fluid has the property of viscosity.

But generally we use ~~Air~~ Air friction damping but not fluid friction damping.

BCZ, Regular meeintance is required in fluid friction damping. fluid may come to outside.

(3) Eddy current Damping:

Eddy > Fluid > Air

↓

order of Effectiveness

Eddy > Air > fluid

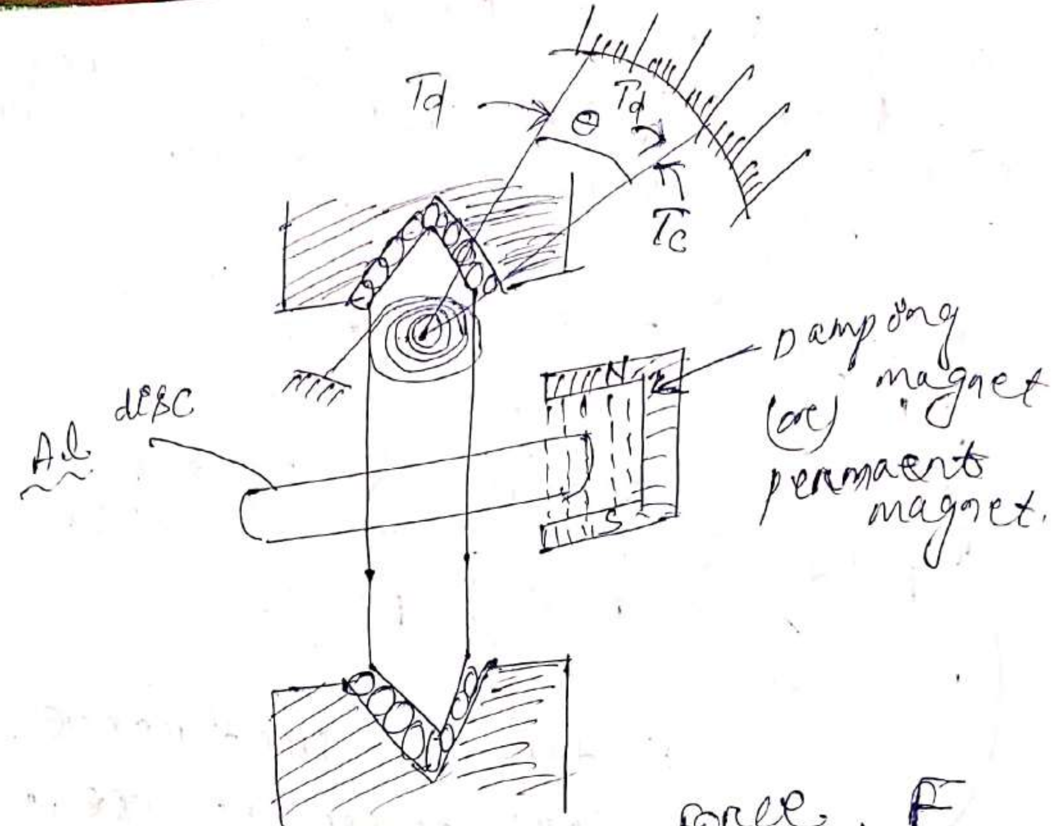
↓

order of preference (or) order of use.

↓ more effective damping

where permanent magnet available ~~is used~~ inside the meter there the damping is ~~we use~~ Eddy current damping.

→ If Electromagnet is available inside the meter then air friction damping is used.



↳ Here I causes force, F causes T_d, so spindle rotates and Al disc rotates. It cuts ~~mag~~ continuous magnetic lines. and E.m.f. is induced on Al disc. so $I = V/R$ is produced.

I ↓ Effect

R ↓ Resistance of Al disc.

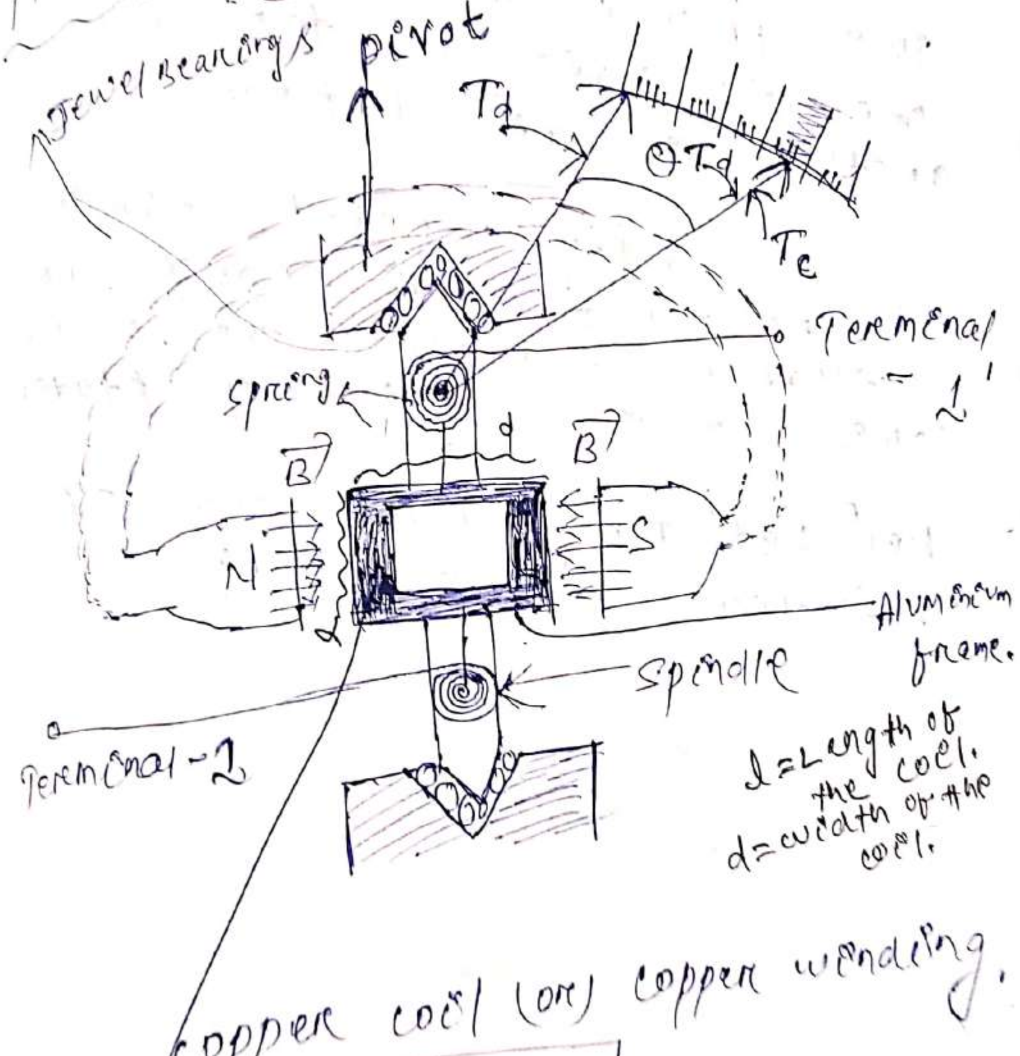
According to Lenz's Law Effect opposes cause.
cause = spindle Rotation.
so spindle Rotation decreases.

I is called eddy current.
Eddy current we can not collect.

permanent magnet gives constent magnetic field. so Damping is constant. BUt Electro magnet gives variable magnetic field, so variable Damping we will get.

—x—

PMMC Instrument :-



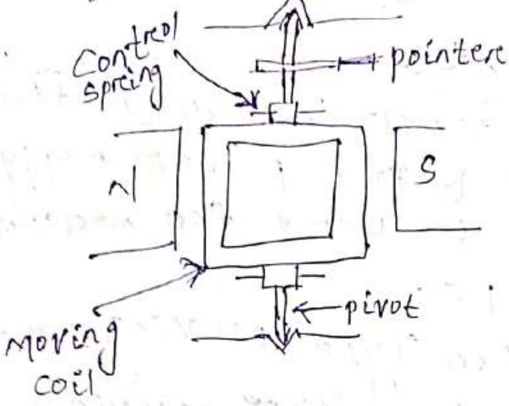
$$\boxed{F = BIL\cdot\sin\theta}$$

→ when I flows through 1-1' then it passes through copper coil, so a force is created due to current carrying coil

PMMC (d'Arsonval Instrument):-

principle:- It works on Electromagnetic effects of current.

"when a current carrying conductor is placed in a magnetic field, it is acted upon by a force which tends to move it one side and out of the field"



Deflection Torque

T_d = Force × ⊥ distance

= N·B·I·l×d

= N·B·I·A

Let, B magnetic field constant.

$T_d \propto I$, $T_c \propto \theta$

$T_d = T_c$

$\Rightarrow \cancel{\alpha}\ \boxed{I \propto \theta}$

Advantages:-

① Low power consumption.
② possess high torque/weight ratio.
③ No hysteresis loss.
④ ~~Eve~~ Effective and Efficient Eddy current damping.

Disadvantages:-

① cannot be used for AC measurement.
② costlier as compare to moving iron Instrument.
③ Friction & temperature might introduce some errors.
④ Ageing due to control spring, permanent magnets.

DC Instrument:- Here deflection ∝ I or V
DC measurement can be done.
EX:- PMMC

AC Instrument:- This instrument utilises Electro-magnetic Induced current for their operation.
AC measurement can be done.
AC instrument.
EX:- Induction instrument.

Absolute Instrument:- It gives the quantity to be measured in terms of instrument constant and its deflection.
EX:- Tangent Galvanometer.

~~sec~~

Secondarey Instrument :- These Instrument are required to be calibrated by comparision with either an absolute (or) secondarey instrument already calibrated.

- → Indicating Instrument.
- → Recording "
- → Integrate "

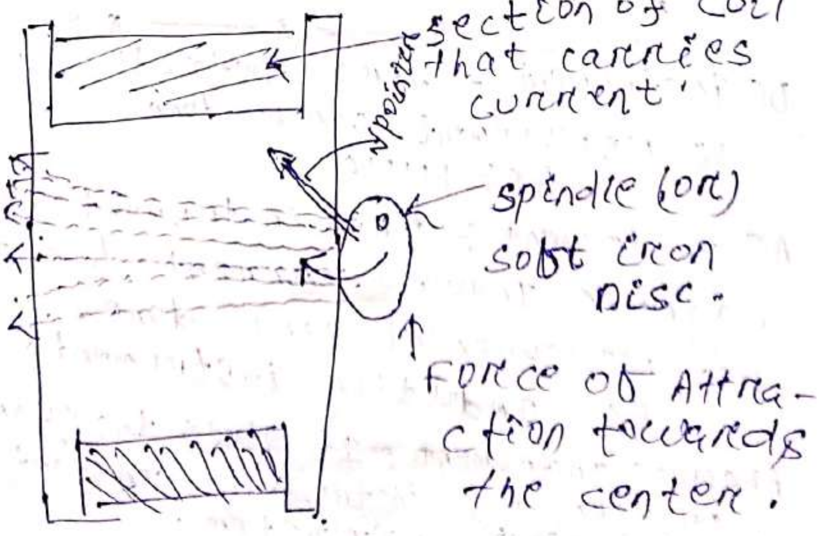
Moving Iron Instrument :-

↳ These are cheap. ↳ simple in construction.
↳ They are accurate at fixed power supply frequency. ↳ It can be used for measurement of both AC and DC.

Types :- ① Attraction Type moving Iron instrument. ② Repulsion Type moving Iron instrument.

① Attraction Type moving Iron instrument :-

prenciple :- when a soft iron piece is placed in a magnetic field of a current carrying coil, it is attracted towards the center of coil. soft iron piece exhibit minimum resistance of force towards the center of coil.

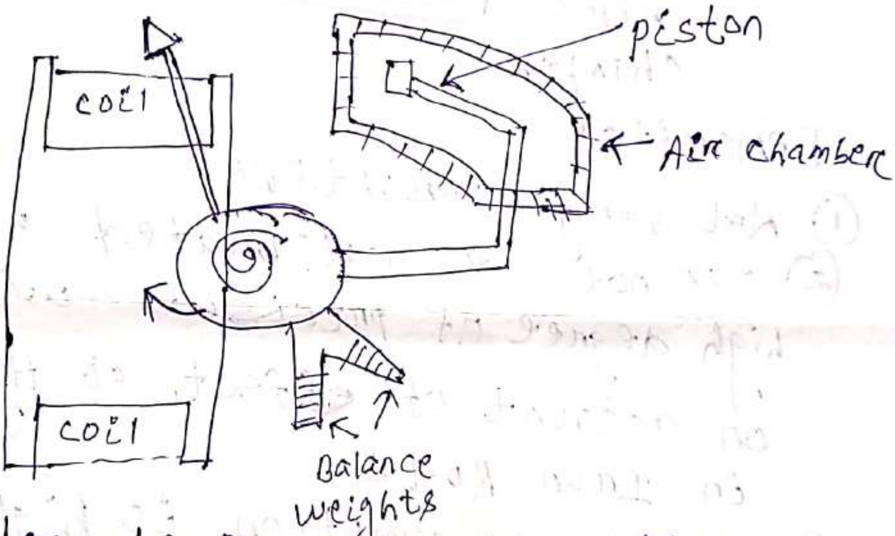


working :-

↳ when instrument is connected to the ckt, the operating current flows through stationary coil. operating current is the current which we will measure by the instrument by applying voltage.

↳ A magnetic field is setup and soft iron piece is magnetised which is attracted towards the center of coil.

↳ Thus, the pointer attached to the spindle is deflected over the calibrated scale.



↳ Td depends on force acting on Iron piece.

F (force) ∝ m·H.

m → pole strength of soft Iron disc

H → Field strength produced by coil.

Again $m \propto H \Rightarrow F \propto H^2$

Again $H \propto I$ so $F \propto I^2$

$Td \propto F \Rightarrow Td \propto I^2$, we know $Tc \propto \theta$

$Td = Tc$ when pointer stops.

$\Rightarrow \theta \propto I^2 \Rightarrow$ Deflection ∝ square of current.

② Repulsion Type Moving Iron Instrument :-

PRINCIPLE :- Repulsive force act when two similarly magnetised Iron pieces are placed together.

Working :- when the instrument is connected to the circuit, the operating current flows through the coil.

↳ A Magnetic ~~field~~ field is set up along the axis of coil.

↳ The field magnetises both the Iron pieces similarly (same polarities.)

↳ A Force of Repulsion act between the two, therefore movable piece move away from the fixed piece.

↳ Thus, pointer attached to the spindle deflects over the calibrated scale.

Deflecting Torque :- It depends upon Repulsive forces between similarly magnetised Iron pieces.

$H \rightarrow$ Field strength produced by coil

$m_1 \rightarrow$ pole strength at fixed Iron.

$m_2 \rightarrow$ " " of Moving Iron.

$m_1 \propto H$, $m_2 \propto H$

$F \propto m_1 m_2 \Rightarrow F \propto H^2$, $H \propto I$

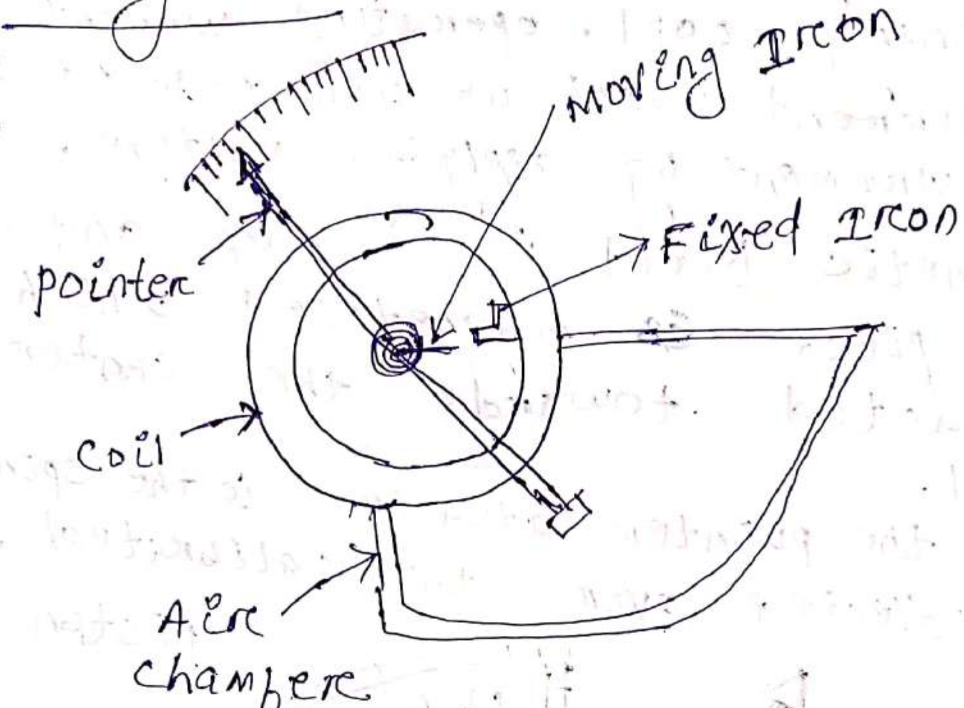
$\Rightarrow F \propto I^2$, $T_d \propto F \Rightarrow \boxed{T_d \propto I^2}$

we know $T_c \propto \theta$, $T_d = T_c$, $\theta \propto I^2$

Demerit :

② Repulsion Type M.I. instrument:-

Diagram:-



Demerits:-

① Not very sensitive.
② can not be calibrated with a high degree of precision with dc on account of effect of Hysteresis in Iron Rods.
③ power consumption is high.

—— x —— x ——

Torque Equation of Moving Iron Instrument :-

The force (F) pulling the iron disc towards the magnetic field of the coil depends upon:

(i) The strength of the magnetic field (H) produced by the coil. and

ⓘⓘ The pole strength (m) developed by the disc, which is also proportional to H i.e.

$F \propto mH$

Deflecting Torque $T_d \propto F \propto H^2$

If relative permeability of material of disc assumed to be constant, then

$H \propto I$ (or) $T_d \propto I^2$ —— ①

Now, for spring control, the controlling torque of spring $T_c \propto \theta$ (Angle of deflection of disc) —— (ii)

In steady state of deflection of the disc, we have Deflecting torque, T_d = controlling Torque, T_c —— (iii)

From eqn ①, (ii) & (iii), we get $\theta \propto I^2$

It shows that the deflection in iron disc is proportional to the square of the rms value of operating current.

sensitivity:- It is the ratio of the change in output of the instrument to a change of input (or) measured quantity. The sensitivity of an instrument should be high.

$$\text{sensitivity} = \frac{\text{change in output}}{\text{change in input}}$$

Accuracy:- It is the closeness with which an instrument reading approaches the true value of the quantity being measured. The measured quantity may be different from the true quantity due to effects of Temperature, humidity etc.

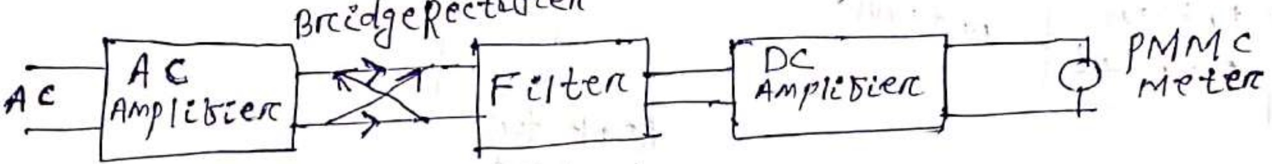
precision:- The term 'precise' means clearly (or) Sharply defined. It is the measure of the reproducibility of the measurements for a given fixed value of a quantity.

Resolution:- It is the smallest change in a measurement variable to which an instrument will respond is called Resolution.

——x——x——

AC Voltmeter with Rectifier and Amplifier Combination :- [3rd sem. EMI ; AC Voltmeter.]

construction :-



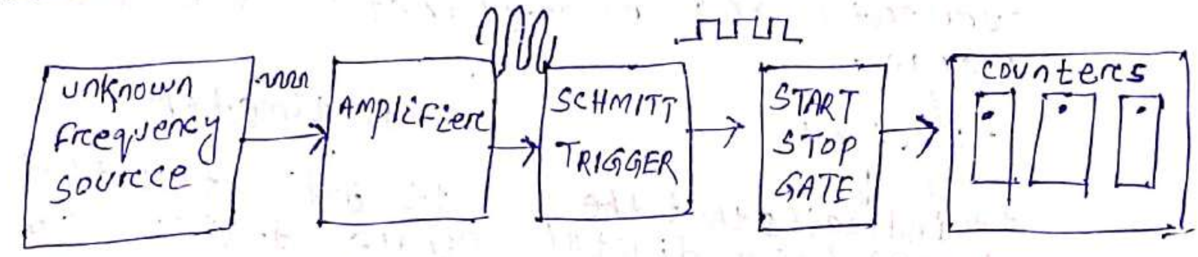
working :- when the AC signal (voltage) is applied to an AC amplifier, it is amplified. and this amplified signal is fed to the rectifier circuit. The Rectifier converts AC in to the pulsating DC. The pulsating DC is passed through the filter ckt. where the pulsating DC is converted in to constant DC. Then it is again amplified by a DC Amplifier and then recieved by PMMC meter. The scale of meter is calibrated to give R.M.S. value.

——x——xx——x——x——

EMI 3RD SEM.

DIGITAL FREQUENCY METER :-

construction:-



working operation:- The unknown signal whose frequency is to be measured is fed to a schmitt Trigger. The signal may be amplified through an amplifier before being applied to schmitt Trigger. In schmitt Trigger the signal is converted in to a square wave with very fast rise and fall times. Thus the output of a schmitt Trigger is a train of pulses, one pulse for each cycle of the signal. The output pulses of the schmitt trigger are fed to start stop Gate. when the Gate is open, these pulses pass through the Gate and fed to an electronic counter that counts the frequency of input signal and that is displayed at Digital Display.

The frequency of the unknown signal is given by $f = \frac{N}{t}$, where

f = frequency of unknown signal.

N = No. of count displayed by counter

t = Time interval between the start stop of the Gate.

—— x —— x —— x ——

DIGITAL MULTIMETER :-

↳ It is an instrument which measures A.C. and D.C. Voltages, A.C. and D.C. currents and resistances over a wide range.

Digital
↓
It indicates that the device has a digital (or) LCD output.

Multimeter
↓
It indicates that a single device can be used for multipurpose measurements.

parts of Digital Multimeter :-

① **Display screen :-** It has illuminated display screen for better visualization.

Five digits <
- one for sign value
- four for number representation.

0 to 9 0 to 9 0 to 9 0 to 9
1 2 3 4 5

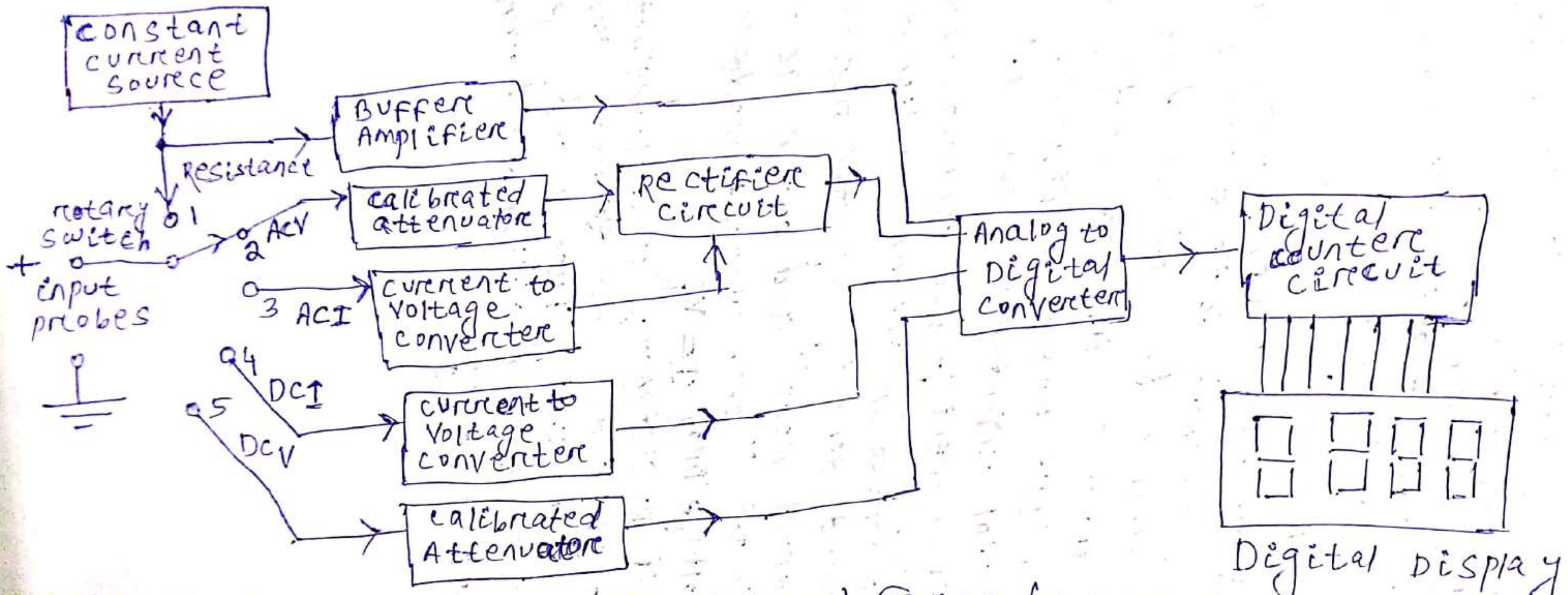
② **Selection Knob :-** multimeter is used for several measurements like voltage, current and resistance. The selection Knob allows the user to select the different measurements.

③ **port :-** Two ports

- (mA)(V)(Ω) port
  - Red preoble
  - It is for +ve terminal
- com port
  - Black probe
  - It is for -ve terminal (or) Ground terminal.

↳ 10A port (current port can measure Large currents.)

BLOCK DIAGRAM OF DIGITAL MULTIMETER :-



① Resistance ② ACV (Alternating Voltage) ③ ACI (Alternating current.)
④ DCI (Direct current) ⑤ DCV (Direct Voltage)

↳ The current is converted into voltage by passing it through low shunt resistance.

↳ The A.C. quantities are converted into D.C. quantities by employing various rectifier and filtering circuits.

↳ The resistance measurements consists of a low current source that is applied across an unknown resistance.

Various Applications:-

① Measurement of voltage:- For measurement of a.c. voltage, the input voltage is fed through a calibreated, compensated attenuatore, to a precision full wave rectifier followed by a ripple reduction filter. (Analog to Digital converter is also used.)

② Measurement of current:- For current measurement, the drop across an internal calibrated shunt is measured directly by the ADC in the "d.c. current mode" and after a.c. to d.c. conversion in the "a.c. current mode".

Resistance Voltage Drop $I = V/R$

③ Measurement of Resistance:- Digital Multimeter measures the voltage across the externally connected resistance, resulting from a current forced through it from a calibrated current source. $V = IR \Rightarrow R = V/I$

—— x ——

———x——— x ———

SIGNAL GENERATOR :- [CHAPTER-7]

↳ It is an instrument which provides different output waveforms including sine wave, Triangular wave, pulse Train and an amplitude Modulated waveform.

↳ It provides variety of different signals for testing various electronic circuits at low powers.

Requirements of a Signal Generator :-

① The output frequency of signal generator should be very stable.

② The amplitude of output signal should be controllable from low values to relatively large values.

③ The amplitude should be stable. The harmonic contents should be as low as possible. The output should be distortion free.

Scanned by CamScanner

④ It should provide Low spurious output.
↓
(free from noise, jitter etc)

Signal Generators :- It generates fixed frequency sine wave whose output can be frequency (or) Amplitude modulated by another signal.

↳ frequency range overwhich instruments a used 0.001 Hz to 50 GHz.

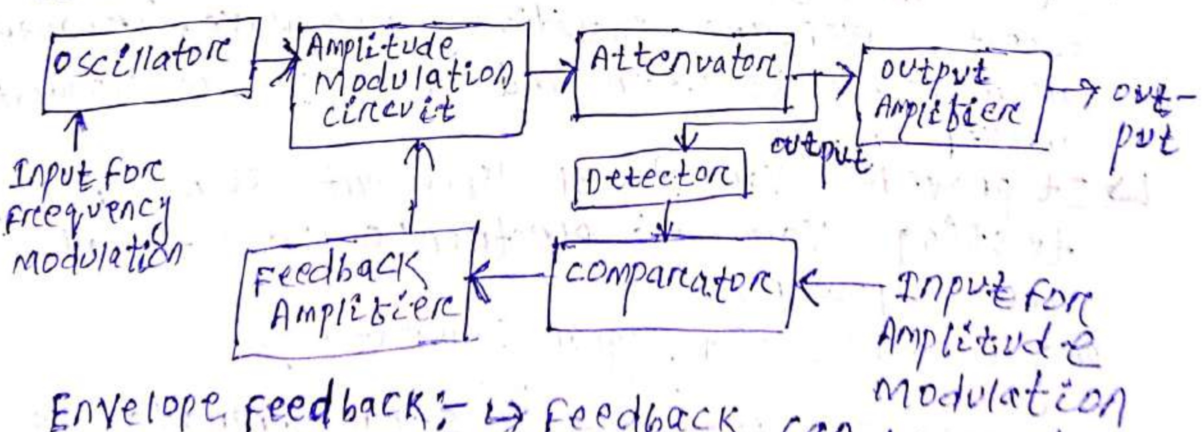
↳ Frequency modulation in signal Generator is achieved by varying the voltage across a variable capacitance diode in the tuning circuit of the oscillator.

↳ Low output distortion for modulation depth below 1% of the carreer frequency.

↳ More output distortion.

↳ Amplitude modulation in signal Generator is done by varying the supply voltage to the oscillator. up to about 50% of value this Amplitude Modulation is done. Amplitude modulation also give phase modulation.

BLOCK DIAGRAM :-



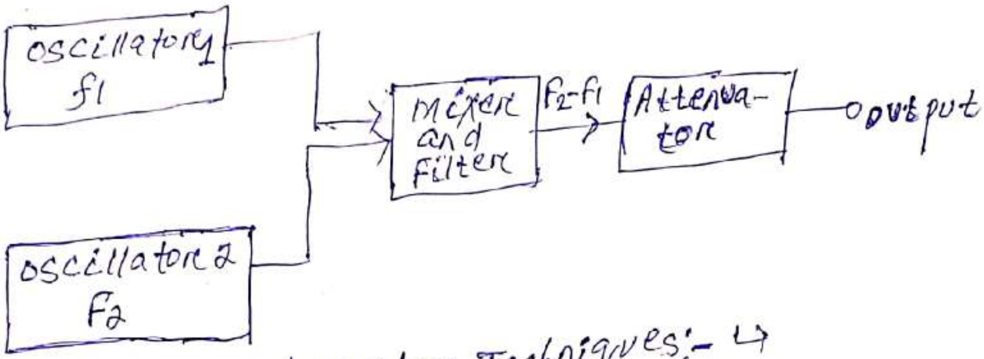
Envelope feedback :- ↳ Feedback can be used to reduce the output Distortion.

↳ Detecting the output to obtain the Modulation envelope.

↳ Comparing this with the amplitude modulation input and then amplifying and feeding back the difference as the modulation signal.

↳ Attenuator is used to give low level output signal and output Amplifier is used to Amplify if the signal is weak.

Heterodyne principle :- It is used to give a continuously variable, wide Frequency range from a single instrument. signal output quality is Good. stability of frequency is very poore. output frequency is $f_2 - f_1$ which is considerable amount of noise and spurious signals.



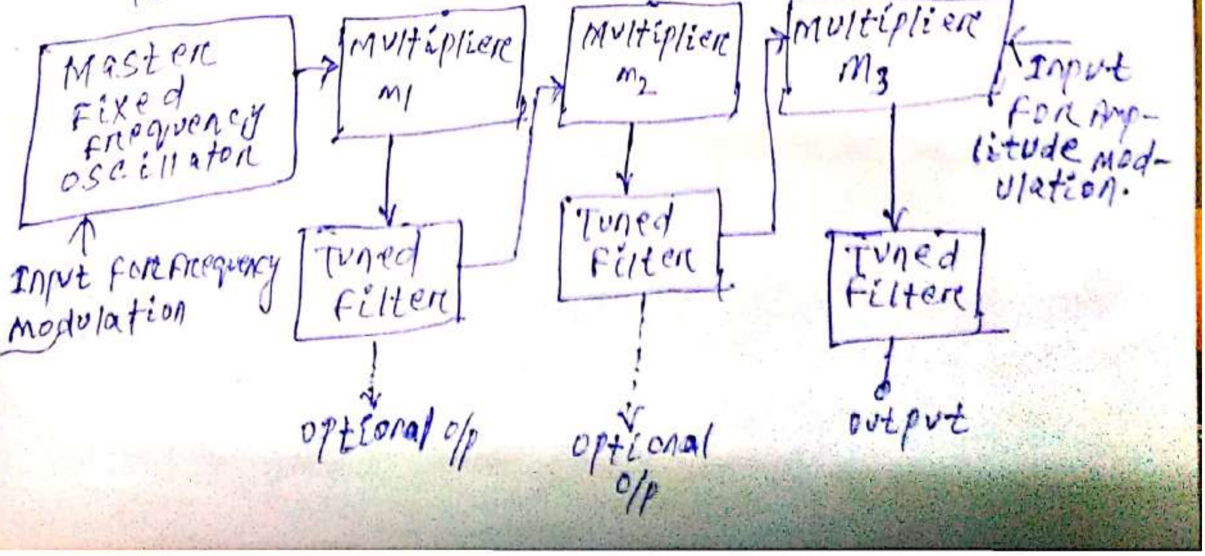
Multiplier and Divider Techniques:- ↳

Multiplier Generator :- output from the fixed frequency oscillator is fed through a series of tuned multiplier.

↳ The output from each stage is fed to a tuned Filter, which selects the high frequency output.

↳ Frequency modulation is applied to Master oscillator.

↳ Amplitude modulation is done by d.c. supply to the last Multiplier stage.

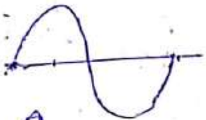


↳ output from the divider stages are square waves which needed to be filtered to produce sine waves.

* * *

DISTORTION :- The process of changing in shape and size of the signal is Distortion.

Example:- original signal →



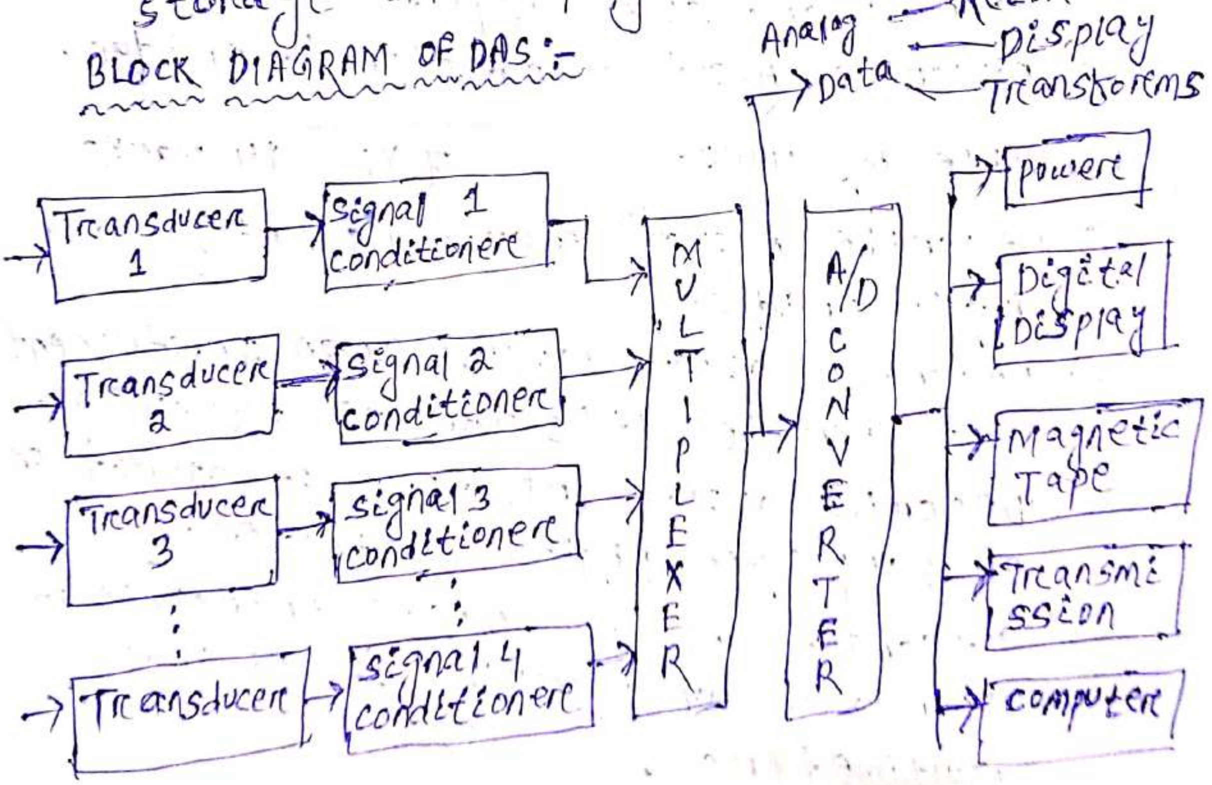
Distorted signal →

→ collecting

DATA ACQUISITION SYSTEM :-

- It is an information system that collects, stores and distributes information.
- It is used in industrial and commercial electronics and environmental and scientific equipment to capture electrical signals (or) environmental conditions on a computer device.
- It includes different tools and technologies that are designed to accumulate data.
- Data Acquisition System consists of :- (i) sensor (ii) signal conditioning (iii) Data conversion (iv) Data processing (v) Multiplexing. (vi) Data Handling (vii) Associated Transmission, storage and Display Devices.

BLOCK DIAGRAM OF DAS :-



TRANSDUCER :- It is used to convert the physical quantity coming from the field in to electrical signals. (or) It is used to measure directly the electrical quantities. (like voltage, current, frequency, resistance.)

SIGNAL CONDITIONING UNIT :-

↳ output signals of transducers are very weak signals which can not be used for furthere processing.

↳ To make the signals strong, various signal conditioners are used.

↓ Different Types are (↳ Amplifiers. ↳ Filters. ↳ Modifiers.)

MULTIPLEXER :- ↳ It accept multiple analog inputs and provide a single output signal according to the requirements.

A/D CONVERTER :- ↳ It converts Analog Data in to Digital Data.

↳ It is used for easy processing, easy transmission and Digital Display, storage is easy.

RECORDERS AND DISPLAY DEVICES :-

↳ Data is displayed in suitable form in order to monitor the input signals.

↳ Example of Display Devices are oscilloscopes, Numerical Displays, panel meters.

↳ Data can be either permanently (or) Temporary stored (or) recorded. Example :- optical recorderes, ultraviolet Recorders, stylis and ink recorders.

OBJECTIVES OF DATA ACQUISITION SYSTEM :-

① The system must acquire the necessary data, at correct speed.

② use of all data efficiently to inform the operator about the state of the input.

③ It must monitor the complete plant operation to maintain on-line optimum and safe operations.

④ It must be able to summarize, and store and record data for diagnosis of operation purpose.

(5) It must be flexible and capable of being expanded for future requirements.

(6) It must be reliable and not have a down time greater than 0·1%.

(7) It must provide an effective human communication system.

(8) Applications/uses of DAS system :-

↳ Analog DAS is used when wide frequency width is required (or) when lower accuracies can be tolerated.

↳ Digital DAS is used when physical quantity being monitored has narrow bandwidth and also when high accuracy and low per channel cost is required.

↳ Digital systems are more complex than Analog systems both in terms of instrumentation involved and the volume and complexity of data they can handle.

↳ These are used in Industrial Area (like plants ~~for~~ collecting Data), scientific Areas (Aerospace, Biomedical, Telemetry for collecting the Data.)

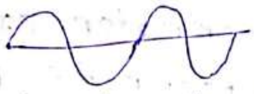
—— x —— x ——

FUNCTION GENERATOR :-

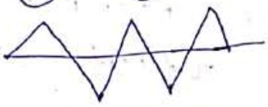
↳ A Function Generator is a signal source that has the capability to produce different types of waveform as it's output signals.

↳ Most common output waveforms are :-

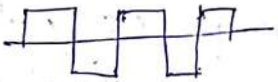
Sine wave



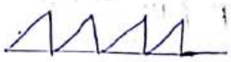
Triangular wave



Square waves



sawtooth waves



↳ The frequencies of these waveforms may be adjusted from a fraction of hertz to several hundred Kilo Hertz.

↳ Function Generators are versatile instruments as each of the waveforms they generate is suitable for a different group of applications.

↳ The various outputs of the generator may be available at the same time.

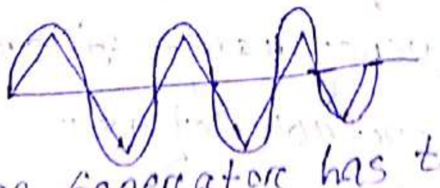
example:- ① square wave + Sawtooth wave

↓ Linearity Measurements in an Audio system.

↓ This signal drive the horizontal deflection Amplifier of an oscilloscope.

② Triangular wave + sine wave.

If the zero crossing of both the waves are made to occur at same time, a linearly varying waveform is available.



↳ Function Generator has the capability of phase locking to an external signal source.

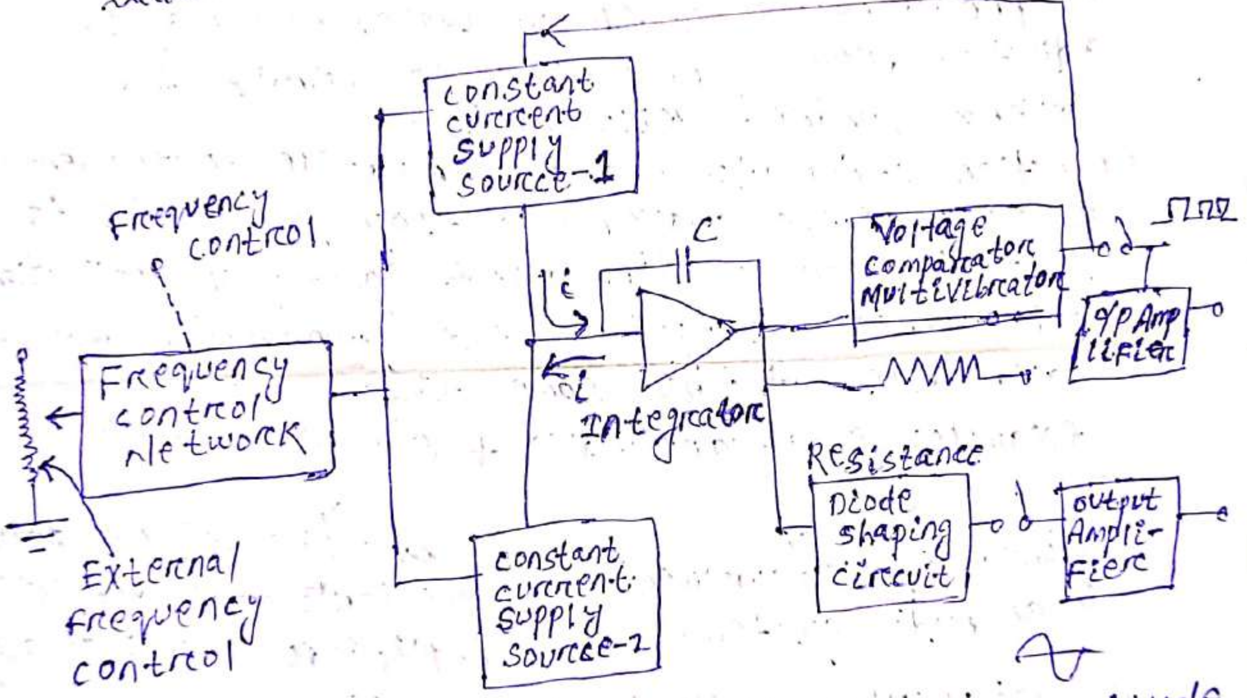
Example:- ① One Function Generator may be used to phase Lock a second function Generator and the two output signals can be displaced in phase by one adjustable amount.

② one function generator may be phase locked to a harmonic of the sine wave of another Function Generator :

By adjustment of the phase and Amplitude of the harmonics almost any waveform may be produced.

③ The function generator can also be phase locked to an accurate frequency standard and all its output waveforms will have the same frequency, stability and Accuracy.

BLOCK DIAGRAM OF FUNCTION GENERATOR :-



↳ The frequency is controlled by the magnitude of the current that drives the integrator.

↳ The 3 Different waveforms sinusoidal, Triangular, square waves are generated in the frequency range of 0.01 HZ to 100 KHZ.

① Frequency control Network

Governed by the frequency dial on the front panel of the instrument.

(or) Governed by an externally applied control voltage.

↳ The frequency control voltage governs/ regulates the two current sources.

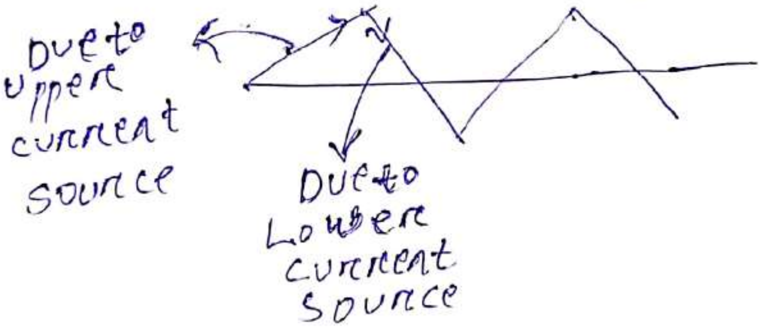
upper current source
Lower current source.

↳ The upper current source supplies a constant current to the integrator whose output voltage increases linearly with time.

$$e_{out} = \frac{-1}{c}\int i.dt$$

↳ A Increase(↑) or Decrease (↓) in current supplied by upper current source increases (↑) or decreases (↓) the slope of the output voltage.

↳ The Lower current source supplies Reverse current to the integrator. Due to Reverse current output voltage decreases linearly with time.



[output of Integrator is Triangular wave.]

↳ The comparator output provides a square wave of the same frequency as the output voltage.

↳ The Resistance Diode network changes the slope of the triangular wave as its Amplitude changes and produces a Sinusoidal wave with less than 1% distortion.

—x—x—x—x—

Analog Multimeter :-

↳ It is used in Laboratory and repairing box.
multimeter means many measurement can be done by single device.

↳ Analog multimeter measures voltage, current, resistances of various ranges.

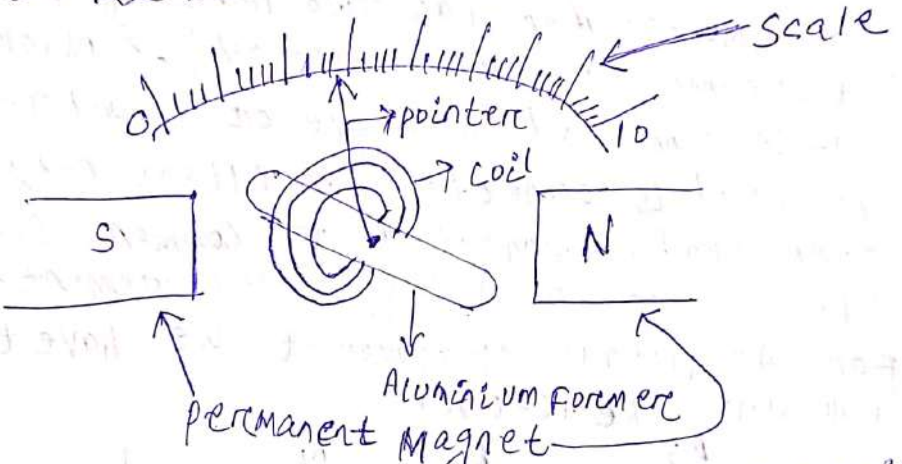
↳ Multimeter
  - Digital (digital o/p displayed at LCD, LED.)
  - Analog. (Analog o/p displayed by pointer on scale calibration.)

↳ Both DC and AC measurements can be done.

↳ Multimeter consists of Voltmeter, Ammeter and ohmmeter.

working principle and construction of Analog Multimeter :-

↳ It is basically a PMMC galvanometer. It has Moving coil that moves in Magnetic field of permanent magnet. Moving coil is wound on an Aluminium former. pointer is attached with Moving coil. pointer moves on a graduated Scale.

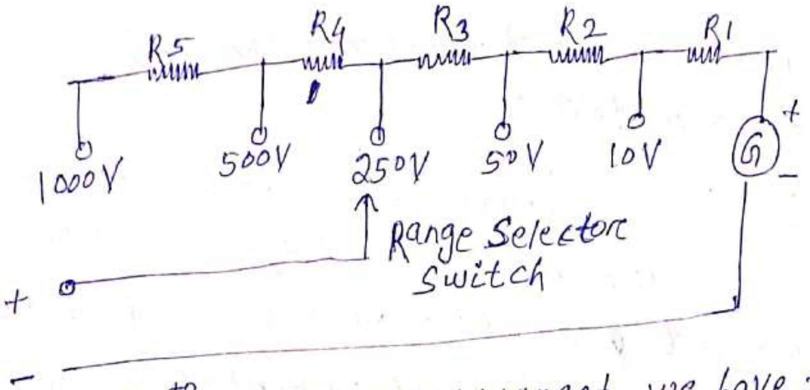


↳ Two spiral Springs are attached to the coil assembly (at the top and bottom) to provide controlling Torque. when input is removed the pointer should return to initial position in the calibrated scale. And it is done by controlling Torque.

↳ Galvanometer is converted into a Voltmeter, Ammeter and ohmmeter with the help of Suitable circuits for measuring Voltage, current and Resistance.

Voltage Measurement by Analog Multimeter :-

↳ High Voltages are measured by connecting high resistances in series with Galvanometer. Similarly Low Voltages are measured by connecting Low resistances in series with Galvanometer. so According to ranges of voltage measured, the resistance ranges varied.



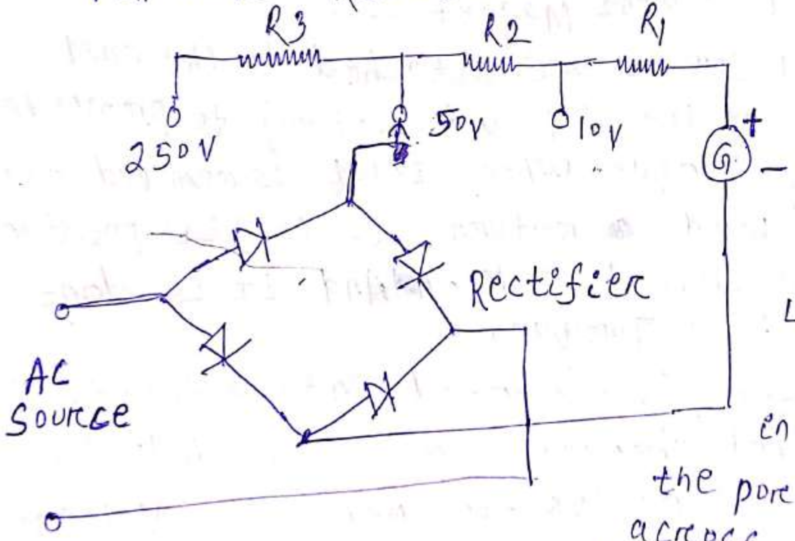
↳ For 0-to 150 Volt measurement we have to connect R1 and R2 with Galvanometer. similarly so on.

↳ Series Resistance is also called multiplier.

↳ Analog Multimeter has Two leads. ① Red Lead (It is connected with +ve terminal), ② Black Lead (It is connected with -ve or Ground Terminal.)

↳ one Lead is connected in Voltage range socket. other Lead is connected to common socket. This is for DC Voltage measurement.

↳ For AC Voltage measurement we have to use Full wave Rectifier.



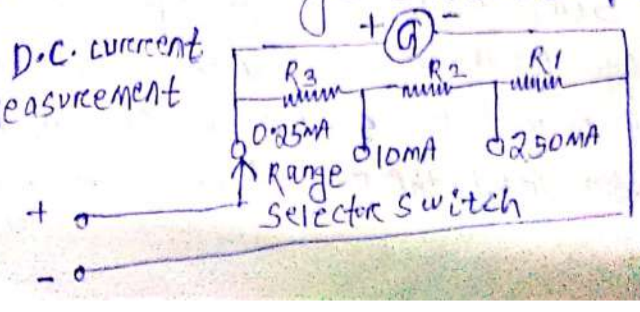
↳ AC voltage Range is selected by selector switch.

↳ Analog Multi-meter is connected in parallel with the portion of the circuit across which Voltage is to be measured.

Current Measurement by Analog Multimeter :-

↳ For current measurement, small resistance is connected in parallel with Galvanometer to measure large current values.

↳ D.C. current Measurement



↳ Range is Selected by Varying the value of shunt Resistance.

↳ Multimeter is connected in series with the branch in which current is to be measured.

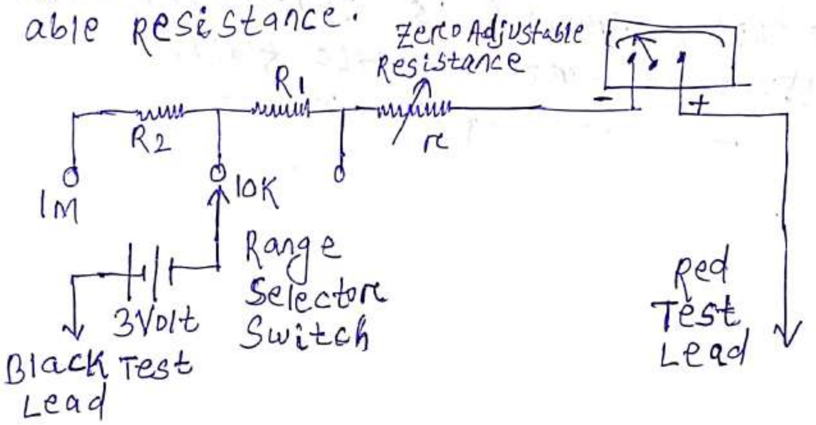
↳ For AC current measurement we will use Rectifier. Rectifier converts AC value to DC value and then measurement is done.

Resistance Measurement by analog multimeter :-

↳ Galvanometer is converted to ohmmeter for resistance measurement. for this conversion Internal battery is connected in series with Galvanometer, Fixed Resistance and Adjustment Resistance.

↳ Red Test Lead is connected to the ckt whose resistance is to be measured.

↳ R1, R2 are fixed resistances and r is Adjustable resistance.



↳ Fixed Resistances limit the current with in the desired range. Variable resistance is used for Zero adjustment in the pointer. Scale is calibrated in terms of resistance.

Sensitivity of Multimeter :-

↳ Resistance offered per unit Volt of Full scale deflection by Multimeter is called sensitivity.

↳ For High sensitivity high internal resistance is used. circuit draws negligible current, so No current loss occurs and correct measurements can be done.

↳ Sensitivity of Analog multimeter ranges from 8 $\frac{K\Omega}{V}$ to $20\frac{K\Omega}{V}$.

Advantages of Analog Multimeter :-

↳ sudden change in signal can be detected effectively. Due to High sensitivity the small current can be detected by Analog multimeter.

↳ All types of measurements can be done by single meter.

↳ Increase (or) Decrease in signal levels can be easily observed.

Disadvantages of Analog Multimeter :-

↳ Analog Multimeters are bulky, costly, care has to be taken. Error can occur due to observer.

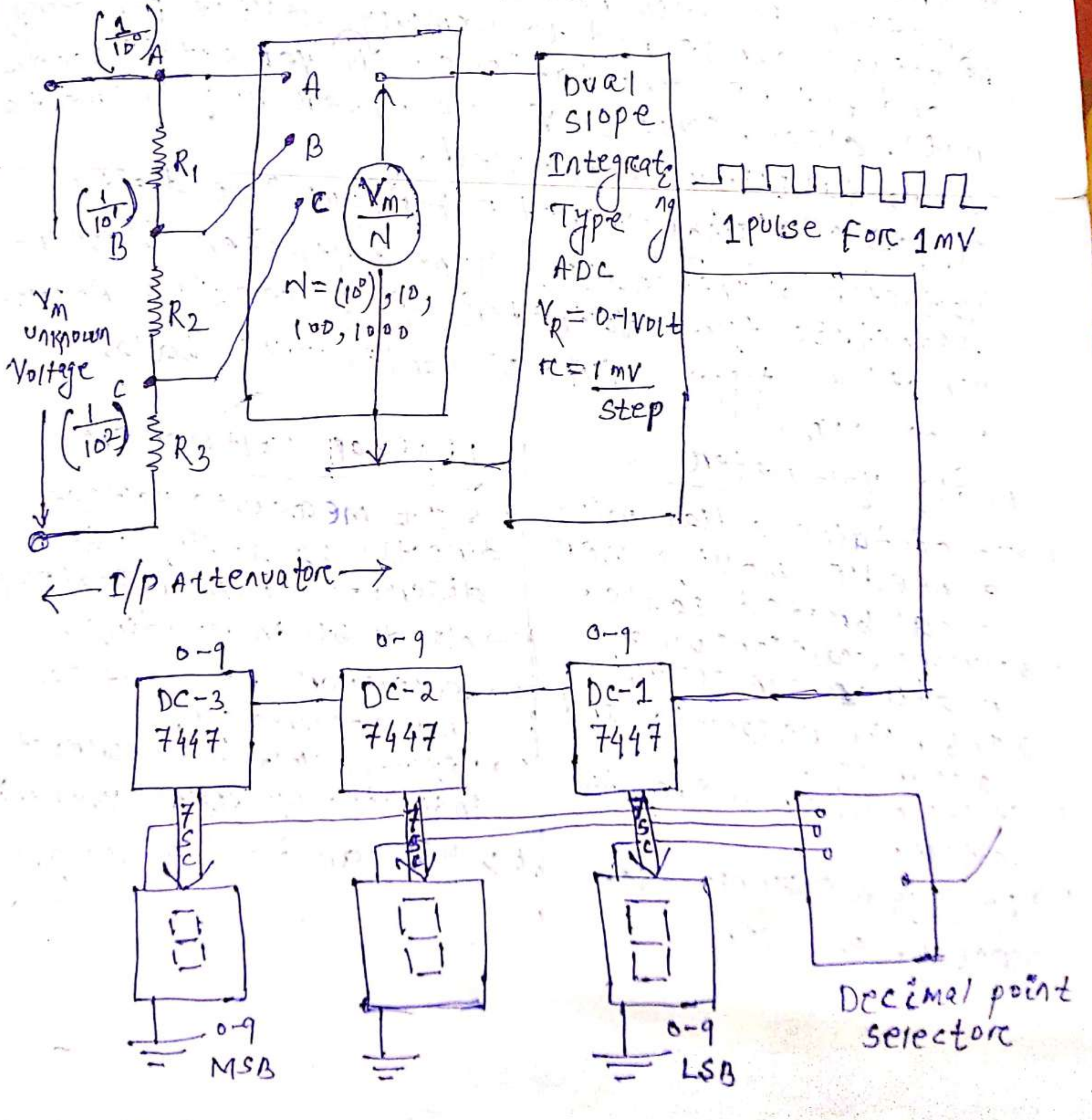
↳ pointer Movement is slow. ↳ Vulnerable to shock and vibration/ at outside envirnment then error occurs in reading.

↳ This instrument is Inaccurate due to effect of earth Magnetic field.

——x——x——x——

Digital voltmeter [ELECTRONIC MEASUREMENT]

→ DVM is voltage sensitive device. In DVM Responsible quantity is voltage.



- 7447 converts BCD to 7 segment display.
- 3 Decade counters are connected in series to count maximum 1000 number of pulses.
- Decade counter that counts BCD value that is equivalent to unknown input value and that unknown input signal is displayed, by 7 segment Display in digital format.
- Decimal point selector selects at which place Decimal point is placed.

Advantages of Digital Voltmeter :- (i) Readout of DVM is easy as it eliminates observational errors in measurement committed by operators.
(ii) Errors on account of parallax and approximation is eliminated.
(iii) output can be fed to memory device for storage and future computations. (iv) versatile, accurate, cheap, compact. (v) Low power requirements.
(vi) portability increased.

Types of Digital Voltmeters :- ① Ramp Type digital Voltmeter ② Integrating Type Voltmeter ③ potentiometric type Voltmeter ④ Successive Approximation type DVM. ⑤ continuous balance Type DVM.

Analog Voltmeter	Digital Voltmeter
It contains a dial with a needle moving over a calibrated scale.	It measure voltage directly by giving the discrete numerical output
wrong scale (or) wrong readings can occur.	No doubt in reading.
Inferior resolution and accuracy.	superior resolution and accuracy.
It can not measure negative voltage.	Negative voltage is correctly indicated by digital voltmeter.
Roughly we cannot use. carefully we use.	we can use it roughly.

G.M.I.T., RAYAGADA

Name of Examination ____________
Date ____________ Sitting - 1st
Regd. No. ____________
Sub. Code & Name ____________
Sem. & Branch ____________
No. of Additionals used ____________

Full Signature of Invigilator

TRANSDUCER AND IT'S CLASSIFICATION :-

Transducer is a device which converts one form of Energy in to another form of Energy.

CLASSIFICATIONS :- ① primary and secondary Transducer ② Active and passive Transducer.
③ Analog and Digital Transducer.
④ AS Transducer (Electrical Transducer) and Inverse Transducer.

↳ primary Transducer is used at first stage where we want to measure the input quantity. secondary Transducer is used at second stage.

Example :- we give pressure as measuring quantity to Bourden Tube (primary Transducer.) output of Burden Tube is size change or Displacement That value is given as input to LVDT (secondary Transducer) at second stage.

↳ Active Transducer does not need any external power supply.

Ex :- solar plate has photovoltaic cells that converts Light signal to electrical signal comes under Active Transducer.

passive Transducer needs external power supply for its operation. Ex :- Bridge circuit measures unknown resistance but it needs extra power supply for its operation.

↳ Analog Transducer converts physical signal to output signal that is inform of scale calibration.

EX:- pressure gauge displays the physical signal at pointer.

Digital Transducer gives output signal in digital form.

EX:- Digital speedometer, inbike gives output in digital form and it's input quantity is wheel Rotation.

↳ Electrical Transducer converts any physical quantity (or) Non electrical quantity in to Electrical signal as output.

EX:- LVDT → It converts Displacement (physical signal) to Electrical signal as output Voltage.

Inverse Transducer converts electrical signal to Non electrical signal.

—x———x———x——x——x——x—

Date__________ Sitting - 1st/2nd
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Sub. Code & Name __________
Sem. & Branch __________
No. of Additionals used __________
Signature of Invigilator

RESISTANCE THERMOMETER :-

↳ It is also known as Resistance Temperature Detector (RTD). It is used for measurement of Temperature.

Principle :- The resistance of a conductor changes when the temperature is changed.

↳ The variation of resistance R with temperature T (^{0}K) can be represented by

$$\boxed{R=R_0\cdot(1+\alpha_1\cdot T+\alpha_2\cdot T^2+\cdots+\alpha_n\cdot T^n+\cdots)}$$

R = resistance of metal, R_0 = Resistance at temperature T = 0 kelvin

$\alpha_1, \alpha_2, \alpha_3, \ldots \alpha_n$ = constants.

↳ Resistance Thermometer uses the change in electrical resistance of conductors to determine the temperature.

CONSTRUCTION :- ↳ positive temperature coefficient materials are used.

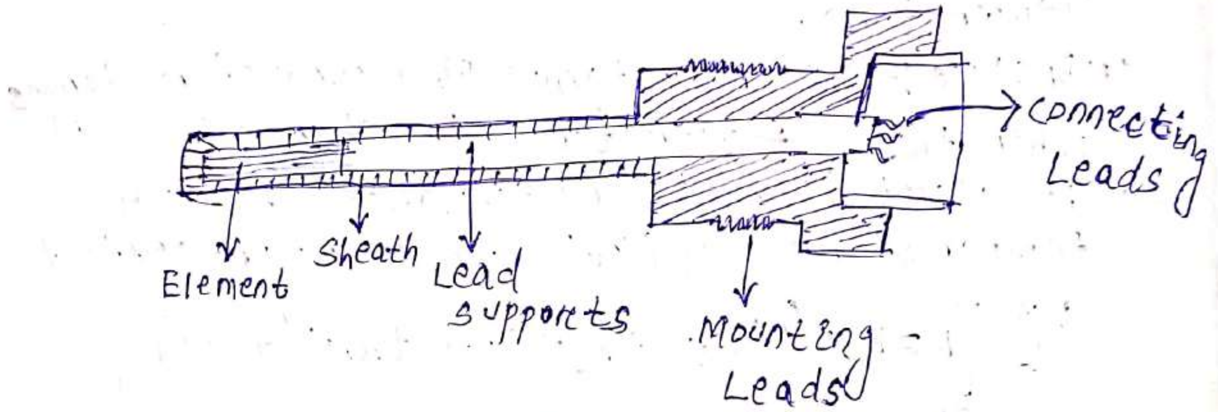
↳ Platinum is used for construction. It can withstand at high temperature having excellent stability. It is less susceptible to contamination.

Requirements of a conductor material to be used in RTD :-

① Change in resistance of material per unit change in temperature should be as large as possible.

② Material should have high value of resisitvity so that minimum volume of material is used.

③ Resistance of materials should have a continuous and stable relationship with temperature.



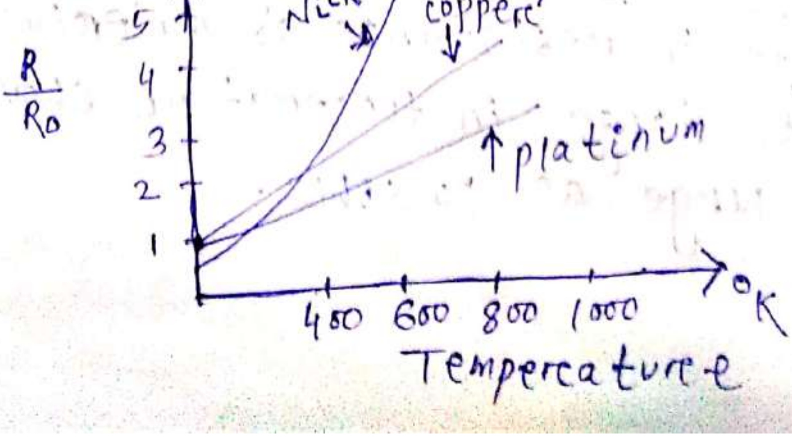
↳ Gold and silver can also be used for RTD construction. They have low resistivities.

↳ Tungsten can also be used. It has high resistivity and it is used at high temperature applications.

↳ copper can also be used.

↳ Mostly we use platinum, nickel and alloys of nickel for construction of RTD.

↳ platinum is the best choice for construction of RTD because platinum has 100 Ω at $0^\circ c$ with a resistance temperature coefficient of $0.00385/^\circ C$



Here 2 Approximations ① Linear Approximation which is used for short range of temperature · ② Quadratic Approximation used for Large range of temperature.

In Linear Approximation

$$R_\theta = R_{\theta_0} \cdot (1 + \alpha_{\theta_0} \cdot \Delta\theta) \text{ with } \theta_1 < \theta_0 < \theta_2$$

R_θ = Approximate resistance at θ°c.

R_{θ_0} = Approximate resistance at θ_0°c.

$\Delta\theta = \theta - \theta_0$ = change in Temperature

: Here Linear Relationship is maintained between the Resistance and Temperature for Short range of temperature.

In Quadratic Approximation we have both Linear part and quadratic part also.

$$R_\theta = R_{\theta_0}\left[1 + \alpha_1 \cdot \Delta\theta + \alpha_2 \cdot (\Delta\theta)^2\right]$$

—x—x—

ELECTRICAL TRANSDUCER :-

→ It converts Mechanical quantity to electrical quantity. It's output is electrical signal.

→ Mechanical Transducer converts Any signal to Displacement.

→ Electrical Transducer has more advantages.

→ In Electrical Transducer Frictionless operation available.

→ Electrical Transducer output can be transferred to more distance.

—x—

Name of Examination

Date Sitting - 1st

Regd. No.

Sub. Code & Name

Sem. & Branch

No. of Additionals used

Full Signature of Invigilator

THERMISTOR :-

→ It opposes the flow of current.

(Thermal + Resistor)

↳ Thermistor is a special type of resistor whose resistance changes with the change in Temperature.

↳ The conductor in which by increasing Temperature, Resistance decreases that has negative Temperature coefficient.

↳ But most of the conductor has positive temperature coefficient i.e. if we increase temperature then Resistance increases.

↳ Thermistor have a negative temperature coefficient of resistance.

↳ 1°c rise in Temperature.

↓

5% decrease in resistance.

↳ Thermistors are used for precision temperature measurements, control and compensation.

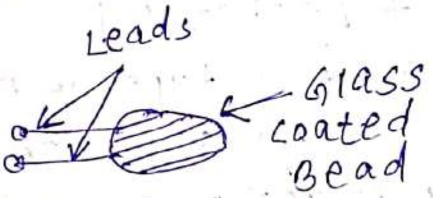
↳ Thermistor temperature measurement range is -60°c to 15°c. Resistance range of thermistor is 0.5Ω to 0.75 MΩ.

↳ Thermistors are highly sensitive but have a non-linear characteristics of resistance versus temperature.

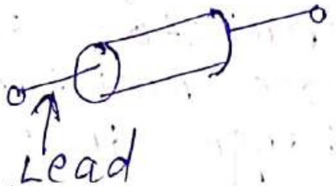
construction :-

↳ It consists metals like Manganese, nickel, cobalt, copper, iron and uranium.

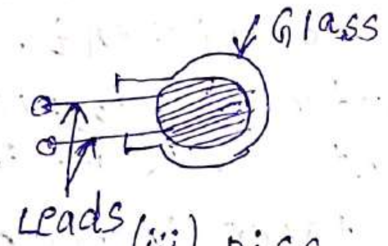
↳ Thermistors are available in different shapes and sizes like beads, rods, discs.



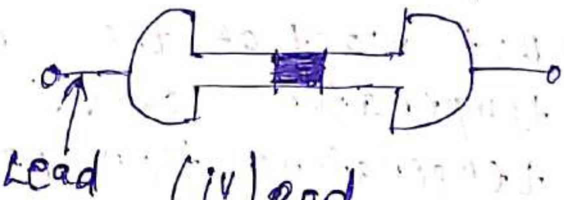
(i) Bead



(ii) probe



(iii) Disc



(iv) Rod

↳ The Thermistor which are Bead in shape they are smallest in size having diameter of 0.015mm to 1.25mm.

↳ Glass probes Types of Thermistor having diameter of 2.5mm and length varies from 6mm to 50mm.

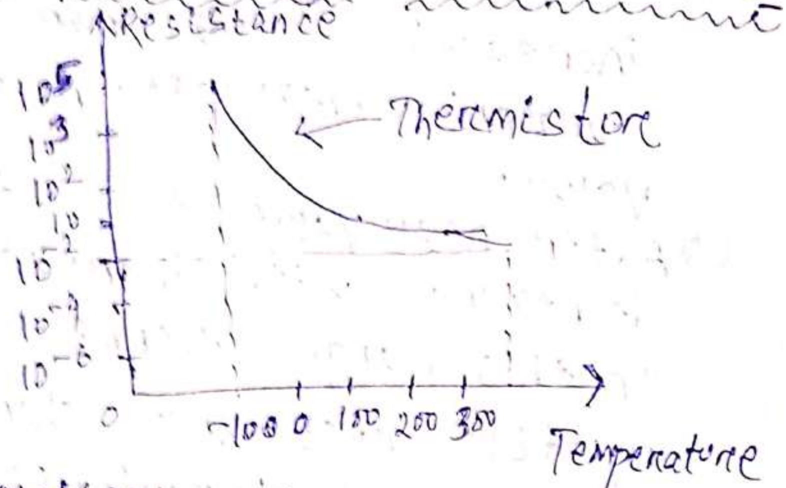
↳ Disc Type of Thermistor made by pressing material under high pressure They are ~~shap~~ sized in to cylindrical shapes with diameter 2.5mm to 25mm.

characteristics of Thermistors :-

① Resistance-Temperature. ② Voltage-current characteristics ③ current-Time characteristics.

① Resistance Temperature characteristics

↳ Thermistor is more sensitive device.



↳ The mathematical expression for the relationship between the resistance of a thermistor and temperature is

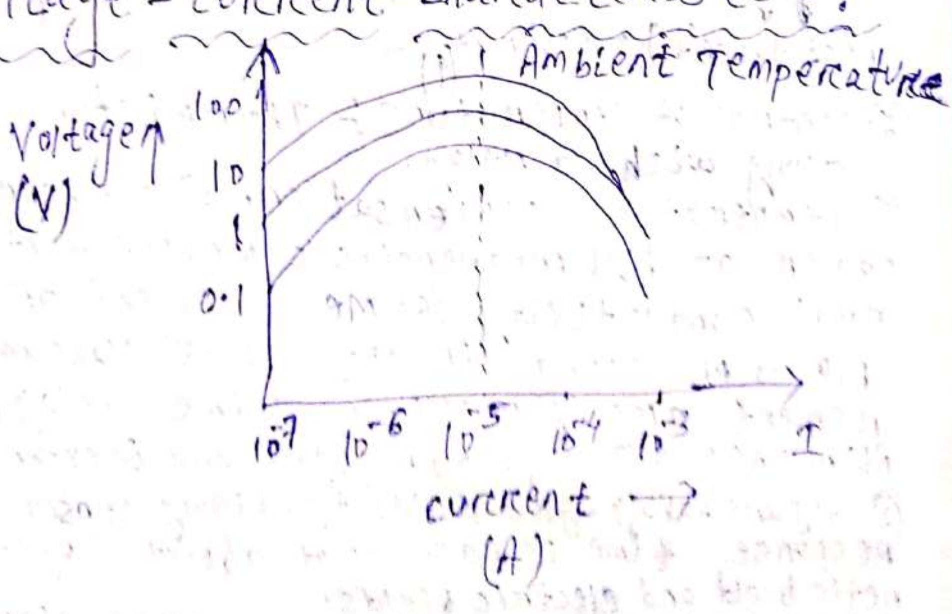
$$R_{T_1} = R_{T_2} \exp\left[\beta\left(\frac{1}{T_1} - \frac{1}{T_2}\right)\right] \ldots\ldots$$

R_{T_1} = Resistance of Thermistor at temperature T_1.

R_{T_2} = Resistance of Thermistor at temperature T_2 ;

β = constant depending upon the material of thermistor. it's Range is 3500 to 4500.

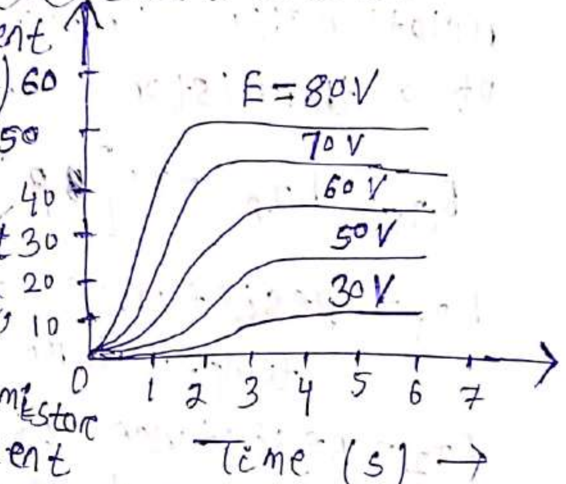
② Voltage - current characteristics :-



↳ The voltage drop of a thermistore increases with ~~[illegible]~~ increasing current until it reaches a peak value.

↳ After peak value the voltage drop decreases with increase in current. In this range thermistor shows the negative resistance characteristics.

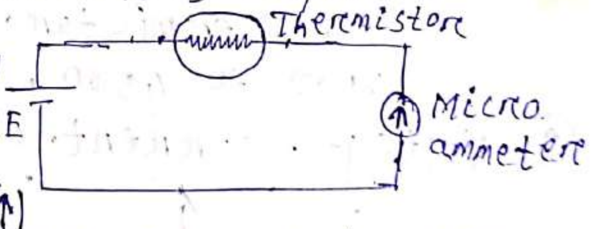
③ Current-Time characteristics :-



↳ The time delay to reach maximum current is a function of applied voltage.

↳ when the heating effect occurs in a thermistor, a certain finite time is required for the thermistor to heat and the current to build up to a maximum steady state value.

APPLICATIONS :- ① Measurement of Temperature.



Temperature (↑)
↕
Resistance (↓) ↔ current (↑)

② control of Temperature :- Thermistor are used along with a relay.

③ Temperature compensation. ④ Measurement of power at high frequencies ⑤ Measurement of thermal conductivity ⑥ Measurement of level, flow, pressure in liquids ⑦ Vaccum measurement also ⑧ providing Time delay.

ADVANTAGES :- ① compact, rugged and inexpensive. ② They are having good stability, highly sensitive. ③ Response time is fast. ④ Not affected by stray magnetic field and electric fields.

DISADVANTAGES :- ① They are having nonlinear characteristics Resistance with Temperature

THERMOCOUPLE TRANSDUCER :-

↳ It is a device which is used for the measurement of temperature Variations. It is also act as Active Transducers. It converts non electrical quantity Temperature to electrical quantity Voltage. It is also Temperature Transducer.

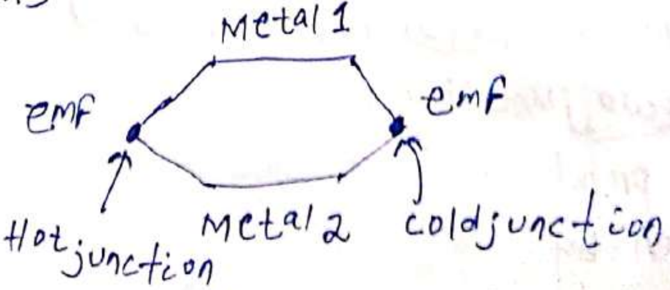
Principle of operation :-

↳ Thermocouple is composed of atleast two metals joined together to form two junctions. There are 2 junctions Hot junction and cold junction. one junction is connected to unknown body whose temperature we have to measure. Another junction is at Reference ~~temperature~~ junction and known ~~as~~ temperature we can say. First junction is Hot junction/measuring junction. second junction is Reference/cold junction.

① Seebeck effect :-

↳ This effect states that when two different (or) unlike metals are joined together at two junctions, an electromotive force (emf) is generated at the two junctions.

↳ The amount of emf generated is different for different combinations of the metals.



↳ Here 2 emfs are generated at two junctions i.e. Hot junction and cold junction.

② Peltier effect :-

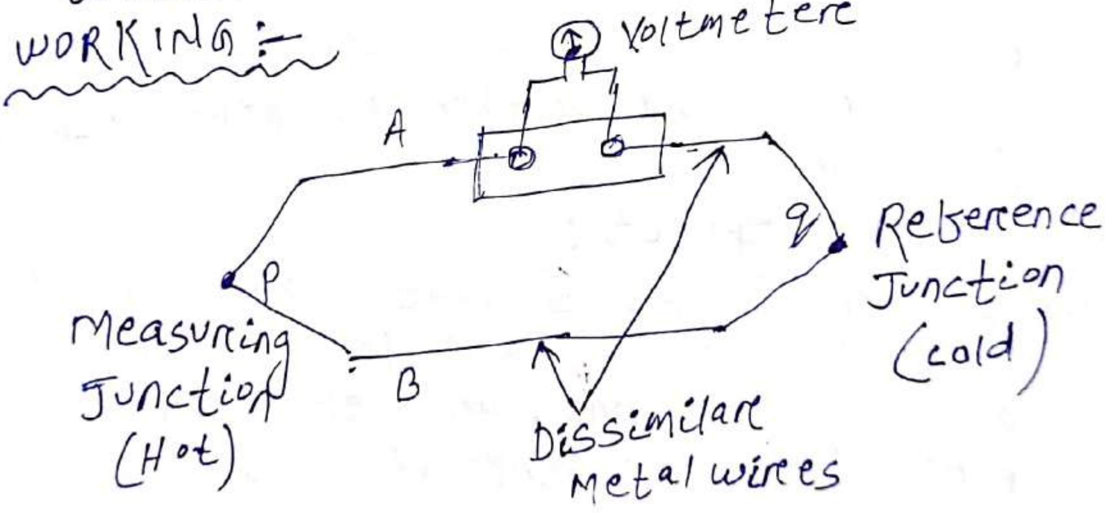
↳ when two dissimilar metals are joined togethere to form two junctions, emf is generated within the circuit due to the different temperatures of the two junctions of the circuit.

↳ In seebeck effect cause of generation of emf was not explained.

③ Thomson effect :-

↳ when two unlike metals are joined together to form two junctions, the potential axis within the circuit due to temperature gradient along the entire length of the conductors within the circuit.

WORKING :-



↳ Thermocouples measures the voltage generated between the two junctions.

↳ The total emf flow in the circuit will depends on metal wires and temperature at two junctions.

↳ The emf produced in the thermocouple is given by

$$E = a\cdot(\Delta\theta) + b\cdot(\Delta\theta)^2$$

$\Delta\theta$ = difference in temperature between the two junctions (°c).

a, b = constants

Generally a >> b, so above equation is approxmately $E = a \cdot \Delta\theta \Rightarrow \boxed{\Delta\theta = \frac{E}{a}}$

↳ In thermocouple temperature measuring circuit, the emf set up is measured by sending a current through a moving coil instrument, the deflection being directly proportional to the emf.

↳ The reference junction is usually at 0°c.

↳ Thermocouples measures up to 1400°c.

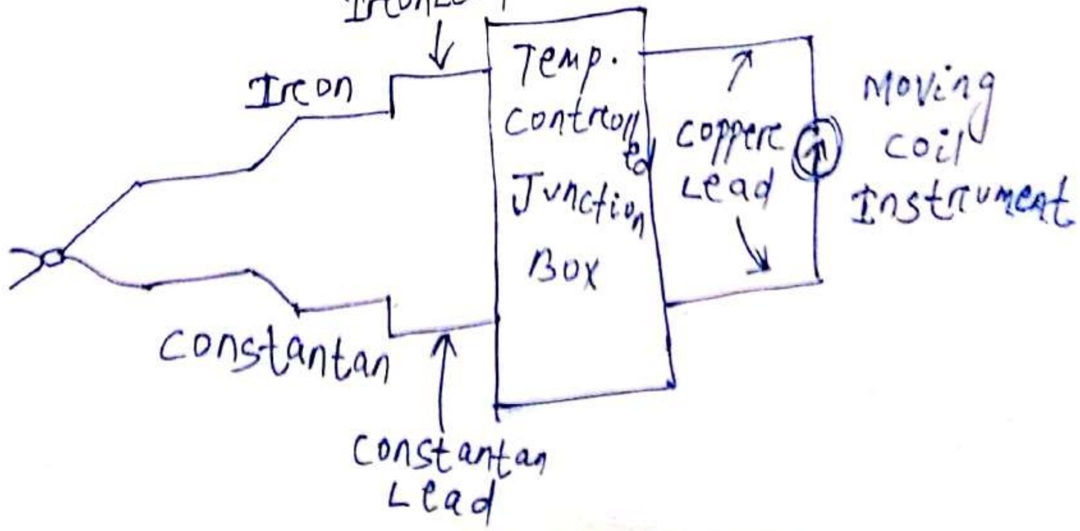
↳ combination of metals used for thermocouple should always produce a linear rise in emf.

$$\boxed{E_0 = a \cdot \Delta\theta}$$

b term → neglected

↳ Different combinations of metals are used to construct the thermocouple. Those metal combinations are

(i) Iron + constantan (ii) copper + constantan (iii) chromel + constantan, (iv) chromel + Alumel (v) Rhodium + Iridium.



The materials that we use in thermocouple that depends on 2 factors. i.e. (i) Kind of atmosphere. (ii) Temperature range to be measure.

↳ Thermocouples are Type of Active transducer. They donot require any auxiliary source for their operation. Thermo couple is also self generating Transducer.

ADVANTAGES:- (i) It follow the temperature changes with a small time-lag.

(ii) They are very convenient for measuring the temperature at one particular point in a piece of apparatus.

DISADVANTAGES:- (i) It has lower accuracy.

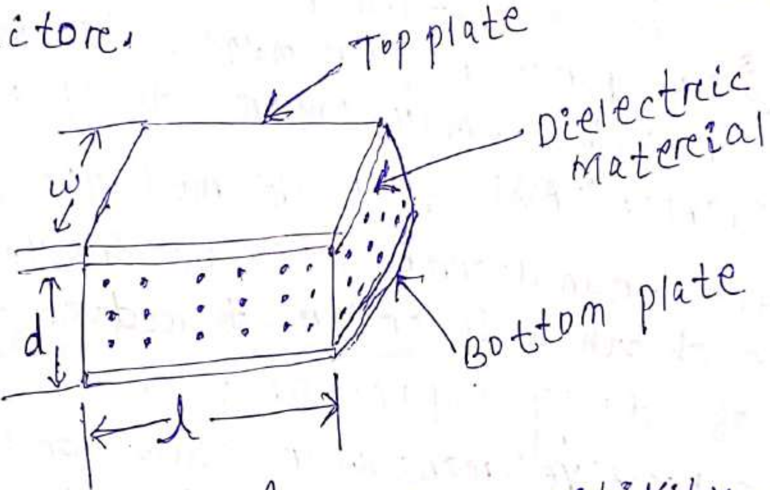
(ii) They should be protect against contamination to ensure long life.

(iii) They should be placed at remote places from measuring devices.

CAPACITIVE TRANSDUCERS :-

↳ It converts a Non electrical quantity into an electrical quantity by means of changes in capacitance. Non electrical quantity may be force, displacement, pressure, flow, Level, Torque etc. Electrical quantity may be Voltage, current.

↳ The principle of operation of capacitive transducers is based on the equation of capacitance of a parallel plate capacitor.



$$C = \frac{\epsilon \cdot A}{d} = \frac{\epsilon_0 \cdot \epsilon_r \cdot A}{d}$$, ϵ = permitivity of the medium $= \epsilon_0 \cdot \epsilon_r$

ϵ_r = Relative permitivity of the Medium.

ϵ_0 = permitivity of free space $= 8.85 \times 10^{-12}$ F/m

A = overlapping area of plates.

d = Distance between two plates.

↳ The capacitive transducer work on the principle of change of capacitance which may be caused by :-

(i) change in overlapping area, A.

(ii) change in distance d between the plates.

(iii) change in dielectric constant.

The above 3 changes can be done by displacement, force, pressure, Liquid level/flow.

↳ The capacitance is measured with bridge circuits. output impedance $X_C = \frac{1}{2\pi f C}$

Advantages of capacitive Transducers :-

① They require extremely small forces to operate them and hence are very useful for use in small systems.

② They are extremely sensitive.

③ They are having Good Frequency response.

④ They are having input impedance so less Loading effect.

⑤ A resolution of the order of 2.5×10^{-3} mm can be obtained.

⑥ The force requirements is small. so it require small power to operate them.

DISADVANTAGES :- ① The metallic parts of the transducers must be insulated from each other in order to reduce the effects of stray capacitances.

② capacitive Transducer show non linear behaviour on account of edge effects. Guard rings are used to eliminate this effect.

③ output impedance is high on account of their small capacitance value which leads to loading effects.

④ The cable connecting the transducer to the measuring point is also a source of error.

APPLICATION/USES OF CAPACITIVE TRANSDUCERS :-

① They can be used for measurements of both linear and angular displacements.

② capacitive Transducers can measure extremely small displacements down to the order of molecular displacements i.e. 0.1×10^{-6} mm.

③ They can be used for measurement of large displacements up to 30m as in aeroplane altimeters.

④ capacitive Transducers can be used to measure the force and pressure.

Force and pressure creates ~~the~~ the displacements and Displacement creates change in capacitance.

⑤ They can also be used as direct pressure transducers in all those cases where the dielectric constant of a medium changes.

⑥ They are used for measurement of humidity in gases.

⑦ They are used in conjuction with mechanical modifiers for measurement of Volume, density, Liquid Level, weight etc.

Liquid Level

↓ changes

Dielectric constant

↓ changes

capacitance

— x — x — x —

LOAD CELL :-

↳ A Load cell is a transducer that is used to convert a force in to electrical signal.

~~[illegible] [illegible] [illegible] common type [illegible] [illegible] gauge load cell.~~

↳ Here pneumatic Load cell is the instrument in ~~[illegible]~~ which we use Air pressure.

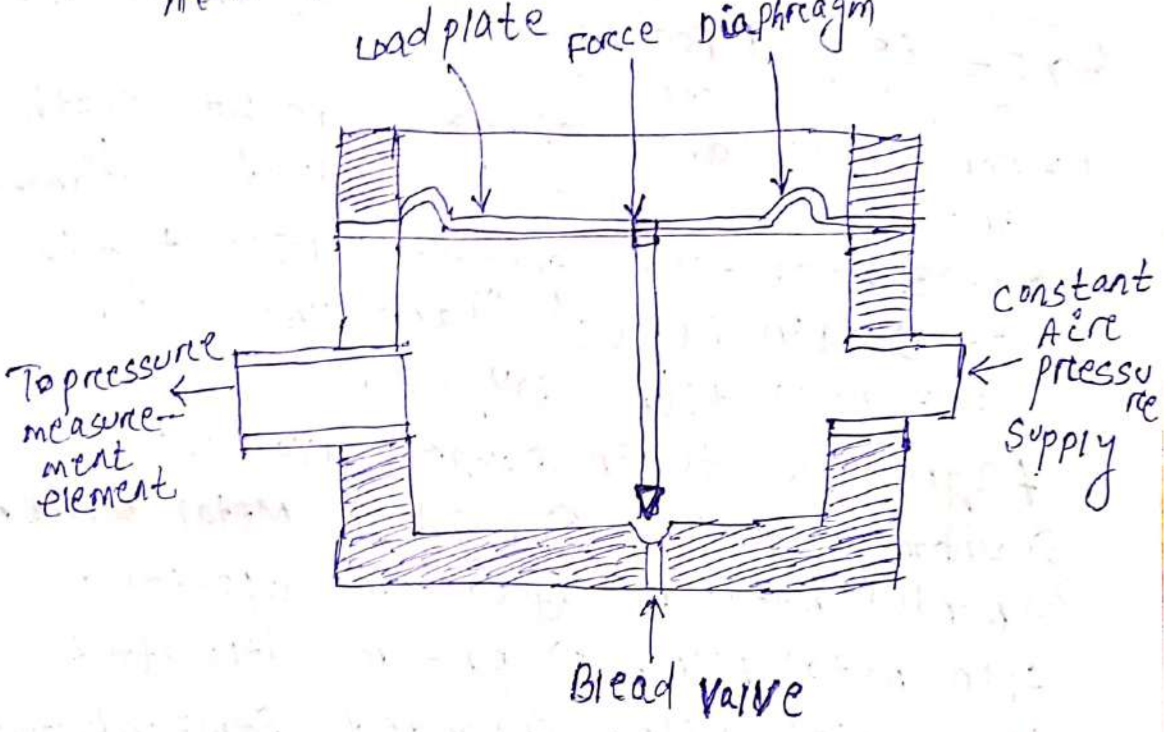


Fig:- pneumatic cell

↳ Here an air chamber is there in which air inlet and air outlet is available. we will measure the Load (or) ~~[illegible]~~ pressure at the output.

↳ Blead valve is controlling ~~[illegible]~~ valve which controls the ~~[illegible]~~ air pressure.

↳ A plate is available on Diaphragm on which we will apply the pressure.

↳ A constant Air supply is maintained inside the chamber.

↳ when we apply Load (or) pressure on Load plate the Diaphragm moves towards downward movement. After that remaining air is removed from outlet chamber. So output air (or) pressure we can measure by the measuring element in form of Load (or) weight.

↳ output Air (or) pressure we are getting due to applied force (or) applied Load.

↳ Here pneumatic means air signal.

—x—x—x—x—x—

STRAIN GAUGE :-

↳ It is used for calculation of strain and associated stress.

↳ Here Resistance changes as both length and diameter of the conductor changes.

↳ ~~piezoresistive gauges.~~ These types of strain Gauges are known as piezoresistive Gauges.

7 Types of strain Gauges available.

① unbonded metal. ② Bonded Metal wire. ③ Bonded metal foil ④ Vaccum deposited thin metal film. ⑤ sputter deposited thin metal film. ⑥ Bonded Semiconductor. ⑦ Diffused metal

① unbonded Metal strain Gauge :-

GAUGE FACTOR :- It is the ratio of per unit change in resistance is to per unit change in length.

ϵ = strain

$$G.F. = \frac{\Delta R/R}{\Delta L/L} = \frac{\Delta R/R}{\epsilon}, \quad = \frac{\Delta L}{L}$$

WORKING :- ① distortion of wheatstone bridge due to tension.

② produces output voltage.

② BONDED WIRE STRAIN GAUGE :-

- ↳ It consists of Grid of fine resistance wire of 0·025mm in diametere.
- ↳ Gauge factor is comparable.
- ↳ size of this strain gauge varies according to different applications from 3mm to 3CM.
- ↳ strain Gauge should have high value of Gauge factor.
- ↳ strain Gauge should have Low resistance/Temperature that helps to error minimization of temperature.
- ↳ strain Gauge should not have any hysteresis effect in its response.
- ↳ Linearity of the function should not be changed.

===x===x===x===

$$\text{stress} = \frac{\text{Force}}{\text{Area}}$$

$$\text{Tension} = \frac{\text{Force}}{\text{unit Length}}$$

PROXIMITY SENSOR :-

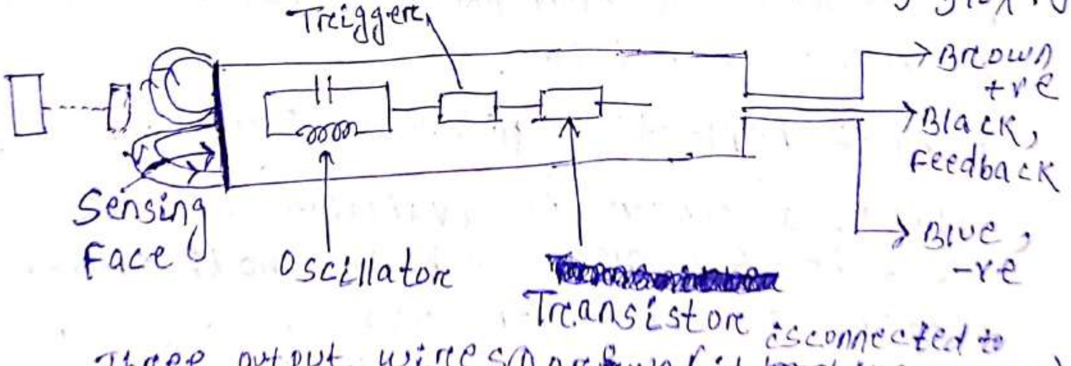
SENSOR :- It is a device that can detect objects without touch.

TYPES OF SENSOR :- ① Inductive sensor. ② capacitive sensor. ③ magnetic sensor. ④ photoelectric sensor. ⑤ Reed switch.

Inductive proximity Sensor :- proximity means nearness. It is the device that senses or detects nearness object by using magnetic effect. Inductive proximity sensor senses the metal object only. It can work for both AC and DC supply. This sensor can sense up to 25mm distance.

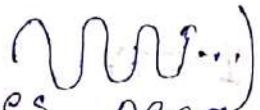
working principle :- It works on the principle of Faraday's Law. According to Faraday's Law induced emf

$$e = -N\cdot\frac{d\phi}{dt}$$ where $\frac{d\phi}{dt}$ = Rate of change of flux.



Three output wires ① Brown (it is connected to +ve supply), ② Black (It is connected to Feedback circuit), ③ Blue (it is connected to -ve supply.)

↳ Let, An object is present at a more distance to sensing face. By connecting +ve and -ve supply to the sensor then magnetic force line is created. when object is far to magnetic force line then oscillator's oscillation

amplitude is high. (like ) .
but when the object comes near to magnetic force line then magnetic force line is compressed and eddy current is created that eddy current also heats the object then oscillator's ~~amplitude~~ oscillation amplitude is zero or decreased. (like ) so current is reduced and Trigger circuit will be on position. so, Transistor also will be in on position. After that finally we will get the output. That output may be +ve (or) -ve .

— x — xx —

PHOTOELECTRIC SENSOR :- It is a light sensitive element that detects the objects. It is available in many forms i.e. AC, DC, Direct Reflection, Reflection with Reflector, Thru Beam, Adjustable operating Distances, programmable output function, DC NPN/PNP, NO+NC selectable AC NO/NC selectable.

Direct Reflection (Diffused) Type sensor :-
Here, a sensor is available in front of this sensor in which both Transmitter and Receiver available. when an object comes in between two sensors then the ~~ray~~ reflected ray/light returns to the sensor by bombarding with object then output is generated.

REFLECTION with Reflector (Retro-Reflective

↳ Here a sensor and a Reflector exist. Transmitter and Receiver remains at same sensor. when object comes in between. them Light output is generated.

Threu Beam Sensor :- Here 2 different sensores are available Transmitter and Receiver. when an object comes in between them then the light output is generated.

——x——x——x——

CURRENT TRANSDUCER :- It is a device which converts current to a propotional standard electrical signal. Basically it is Formed by 4 parts. ① sensitive component ② conversion component ③ conversion circuit ④ power circuit.

WORKING :- The current goes in, sensitive componentgives the electrical signal as output. Then the signal will pass to conversion component which can convert the signal to small current signal. Then it pass to conversion circuit which process the small current signal and provide industry standard Electrical signal (Generally 0 to 5 Volt, 4 to 20 mA, RS485). Then the out signal goes to Terminal equipment (such as Display, PLC, Alarm unit, Automation Control etc.)

↳ current Transducer usually has power circuit which provides power to conversion component and conversion circuit.

Main Functions of Current Transducer:-

① Isolated function.

Here in current Transducer input current is completely isolated to output current.

② Conversion Function.

It converts nonstandard electrical current to Industrial standard Electrical signal which is much easier for terminal equipment and use.

③ Enhance signal for long distance Transfer

It enhance weak current to industrial standard signal so that output signal can transfere to long distance.

ex:- 20mA current can transfer to 1000Km.

④ safety function

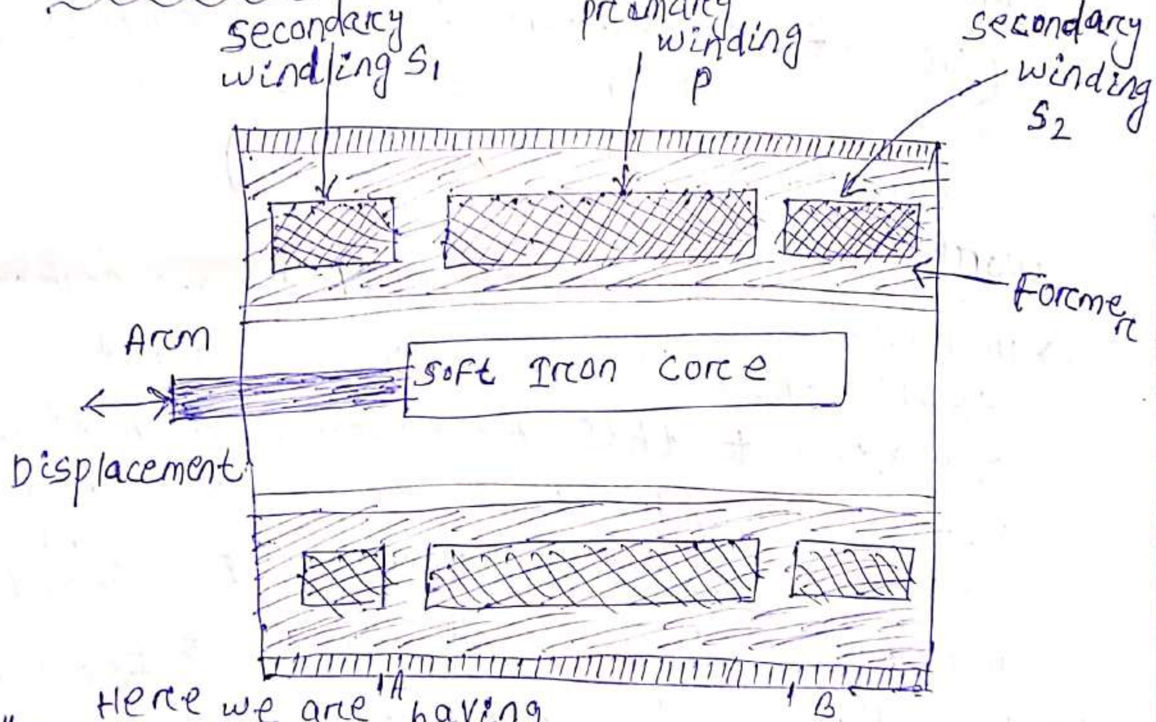
when current Transducers suffer from high voltage then protection mode activates. Input and output is isolated to safety of Terminal equipments. It keeps the whole system safety.

———x———

Linear Variable Differential Transformer (LVDT) :-

- It is a type of inductive transducer which is used to measure the displacement. (→ voltage)
- It convert or Translate the linear motion in to electrical signals.
- Transformer, it has primary winding and secondary winding.
- Differential means output voltage is the difference of the voltages.

construction :-



Here we are having

- single primary winding P, Two Secondary windings S_1 and S_2. These primary and secondary windings wound on a cylindrical Former. Two secondary windings S_1 and S_2 having equal number of turns and are identically placed on either side of primary. primary winding is connected to an alternating current source. soft iron core is placed inside the former.

↳ Displacement to be measured is applied to the arm attached to soft iron core. Soft Iron Core is made upoff high permeability nickel iron which is hydrogen annealed. Due to this Low harmonics, low null voltage and high sensitivity is produced. Soft Iron core is also slotted longitudinally to reduce eddy current Losses.

↳ The whole assembly is placed in stainless steel housing and the end lids provide electrostatic and electromagnetic shielding (i.e. outside electrostatic and electromagnetic field does not affect to operation of inside LVDT.)

working :-

↳ primary winding is excited by a.c. source that produces an electromagnetic field, Due to this Alternating currents, voltages is induced in two secondary windings. Let, the Voltages for secondary windings S_1 is E_{S1} and for S_2 is E_{S2}.

↳ In order to get single output voltage we connect two secondary windings S_1 and S_2 in series opposition.

↳ The output Voltage is difference of the Voltages in the two windings.

$$\boxed{E_0 = E_{S1} - E_{S2}}$$

CASE-1 :- when core is at Null position i.e. middle position, flux linkage to S_1 and S_2 is equal so $E_{S1} = E_{S2}$

$$\Rightarrow \boxed{E_0 = 0}$$

CASE-2 :- when core is moved to the left of Null position, flux linkage to S_1 is more than flux linkage to S_2. i.e. $E_{S1} > E_{S2}$

$$\boxed{\therefore E_0 = E_{S1} - E_{S2}}$$

Here output voltage is inphase with the input voltage i.e. primary voltage.

CASE-3 :- when core is moved to right of Null position, flux linkage S_2 is more than flux linkage to S_1 i.e. $E_{S2} > E_{S1}$

$$E_0 = E_{S2} - E_1$$

Here output Voltage is 180° out of phase with primary voltage.

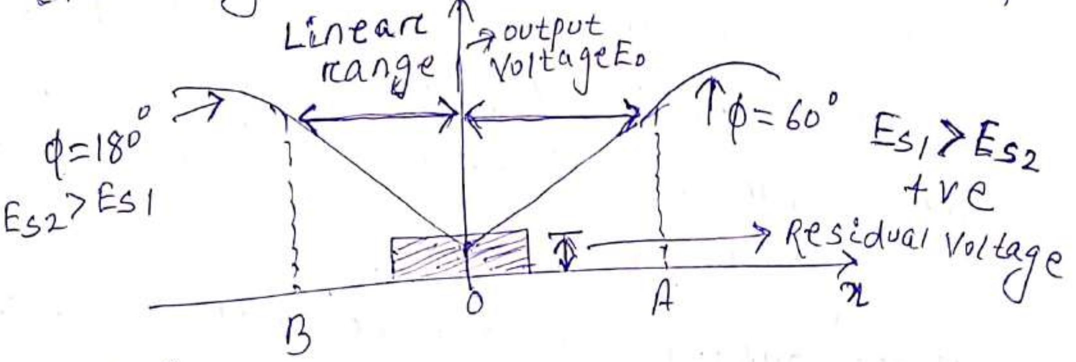
↳ The amount of voltage change in either secondary winding is proportional to the amount of movement of core.

↳ Here nonelectrical quantity Displacement is converted to electrical quantity ~~Vo~~ output Voltage.

↳ The amount of output Voltage may be measured to determine the displacement.

↳ The output signal may also be applied to a recorder (or) to a controller that can restore the moving system to its normal position.

↳ output Voltage of LVDT is a linear function of the core displacement with in a limited range of motion say 5mm from the null position. After 5mm displacement there may be non-linear relationship.



0-A } 5mm
0-B

↳ Residual voltage is small output voltage at null position of soft Iron. Residual voltage created due to ① Due to presence of harmonics in the supply voltage. ② Due to harmonics produced in output Voltage on account of use of iron core. ③ Either an incomplete magnetic (or) electric unbalance. ④ Magnitude of Residual voltage is less than 1% of maximum output

Advantages of LVDT :- ① High range of Displacement that can be measured is 1.25 MM to 250 MM. 0.25% full scale linearity. LVDT can measure Low range of Displacement i.e. 0.003mm. But Dynamic response is Very slow.

② Friction and Electrical Isolation:- No physical contact exist between core and coil. No wear and tear due to friction. No damage of instrument parts. It gives infinite resolution throughout its operating life.

LVDT continued....

(3) Immunity from external effects :-
↳ separation between core and coil permits the isolation of pressurized, corrosive (or) caustic fluids.

(4) High input and High sensitivity :- LVDT give a high output. High sensitivity of about 40 V/mm.

(5) Ruggedness :- LVDT can ~~tolrete~~ tolerate high shock and vibrations.

(6) Low Hysteresis :- LVDT shows low hysteresis. Due to low hysteresis LVDT has good repeatability.

(7) Low power consumption.

Disadvantages of LVDT :-

(1) Relatively large displacements are difficult to measure.
(2) LVDT is very sensitive to stray magnetic and electric fields.
(3) performance of LVDT is also affected by vibrations.
(4) Temperature also affects its performance.
(5) Dynamic response is slow.

Uses and Applications of LVDT :-

(1) primary Transducer (Displacement is converted to output voltage.)
(2) Secondary Transducer. (In case of Bourden Tube, pressure cell LVDT act as secondary Transducer.)

Sub. Code & Name __________

Sem. & Branch __________

No. of Additionals used __________

Full Signature of Invigilator

DIGITAL STORAGE OSCILLOSCOPE(DSO) :-

↳ It is an instrument which gives as the storage of digital form (or) it gives the digital copy of a waveform and it allows us to store the signal(or) waveform in digital format in digital memory and allows us to do the digital signal processing technique over that signal. Oscilloscope gives visual display of waveform

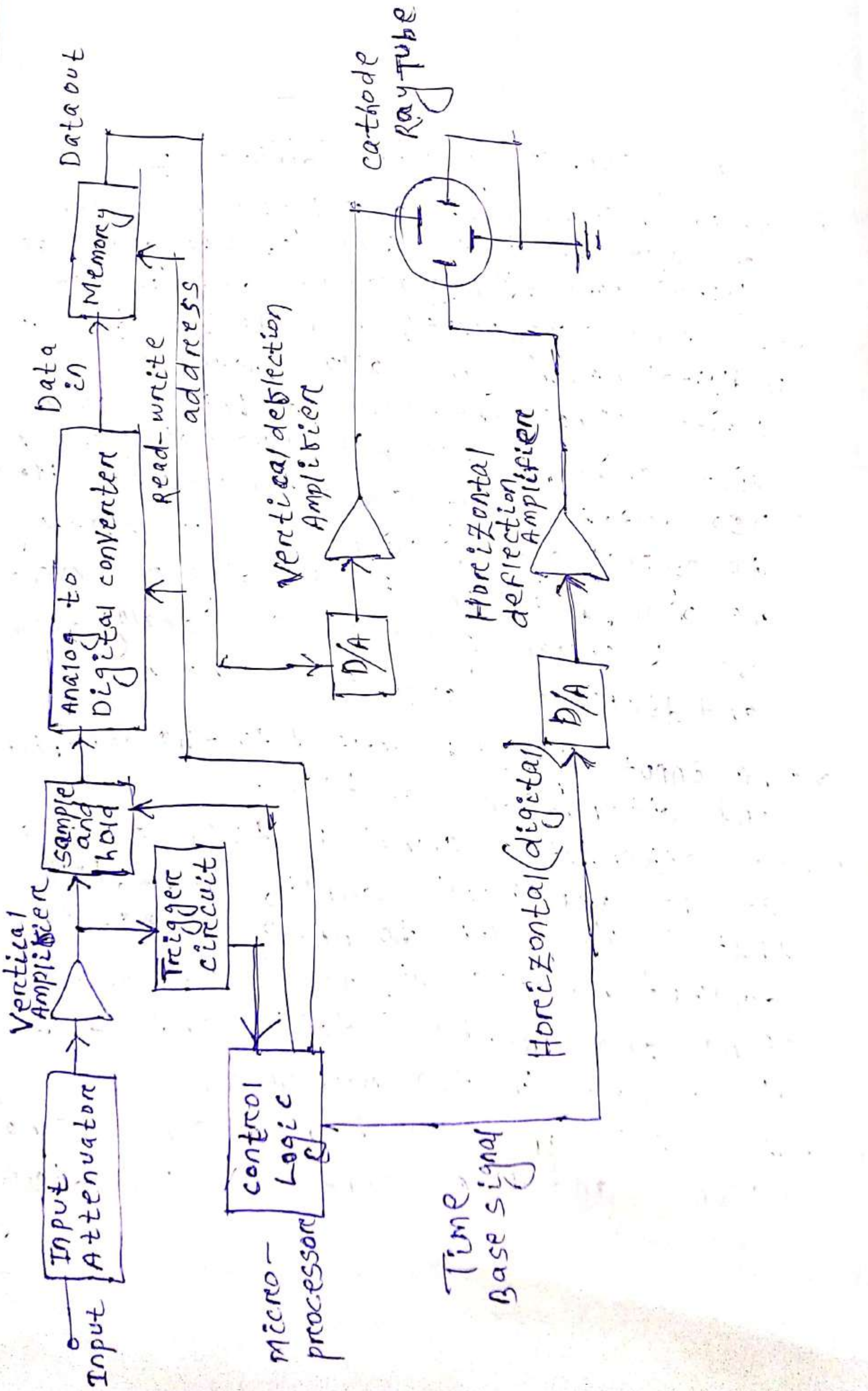
↳ DSO accepts analog signal and converts it to Digital signal, store it in digital memory. And then it is going to convert the signal again in to analog form and displayed over the screen.

↳ The input signal is applied to the amplifier and attenuator section.

↳ The attenuated signal is then applied to the vertical amplifier. After that it is given Analog to Digital converter. ADC digitise the analog signal and create a data set that is stored in the memory.

↳ Data set is processed by the microprocessor and then sent to the display.

BLOCK DIAGRAM OF DIGITAL STORAGE OSCILLOSCOPE:



to

Digital storage oscilloscope works in 3 modes of operation.
① Roll Mode. ② Store Mode ③ Hold (or) save Mode.

↳ In Roll Mode varying signals are displayed on the screen.

↳ In store mode the signal waveforms are stored in the memory.

↳ In Hold (or) save mode, some part of the signal will be hold fore some time instant and then they will be stored at the memory.

Digitising occurs by taking a sample of the input waveform at periodic intervals.

↳ Sampling Theorem states sampling rate must be atleast twice as fast as the highest frequency in the input signal. Aliasing occurs if $f_s \leq 2 \cdot f_m$.

↳ If $F_s \geq 2 f_m$ then Resolution of Analog to Digital converter is decreased.

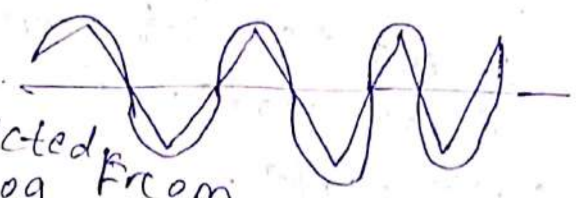
↳ When input signals are stored in analog store register, they can be readout at a much slower rate to the A/D converter and the results are stored in digital store.

↳ It allows operation at upto 100 mega-samples per second. Resolution increases.

Waveform Reconstruction:-

↳ Here signal is converted from Digital form to Analog form.

There are 2 ways in which the wave-forms are reconstructed, Digital form to Analog From form.



Linear interpolation → Here Dots are joined by a straight Line.

Sinusoidal interpolation → Here Dots are joined by a sine wave.

Advantage: ① It display visual as well as numerical values by analyzing the stored traces. (Sampling values at different instant times we can get)

② The Display traces can be magnified and also we can change the brightness of the traces and minute detailing can be done.

③ DSO can display 3-D figure (or) Multiple waveforms for comparison purpose.

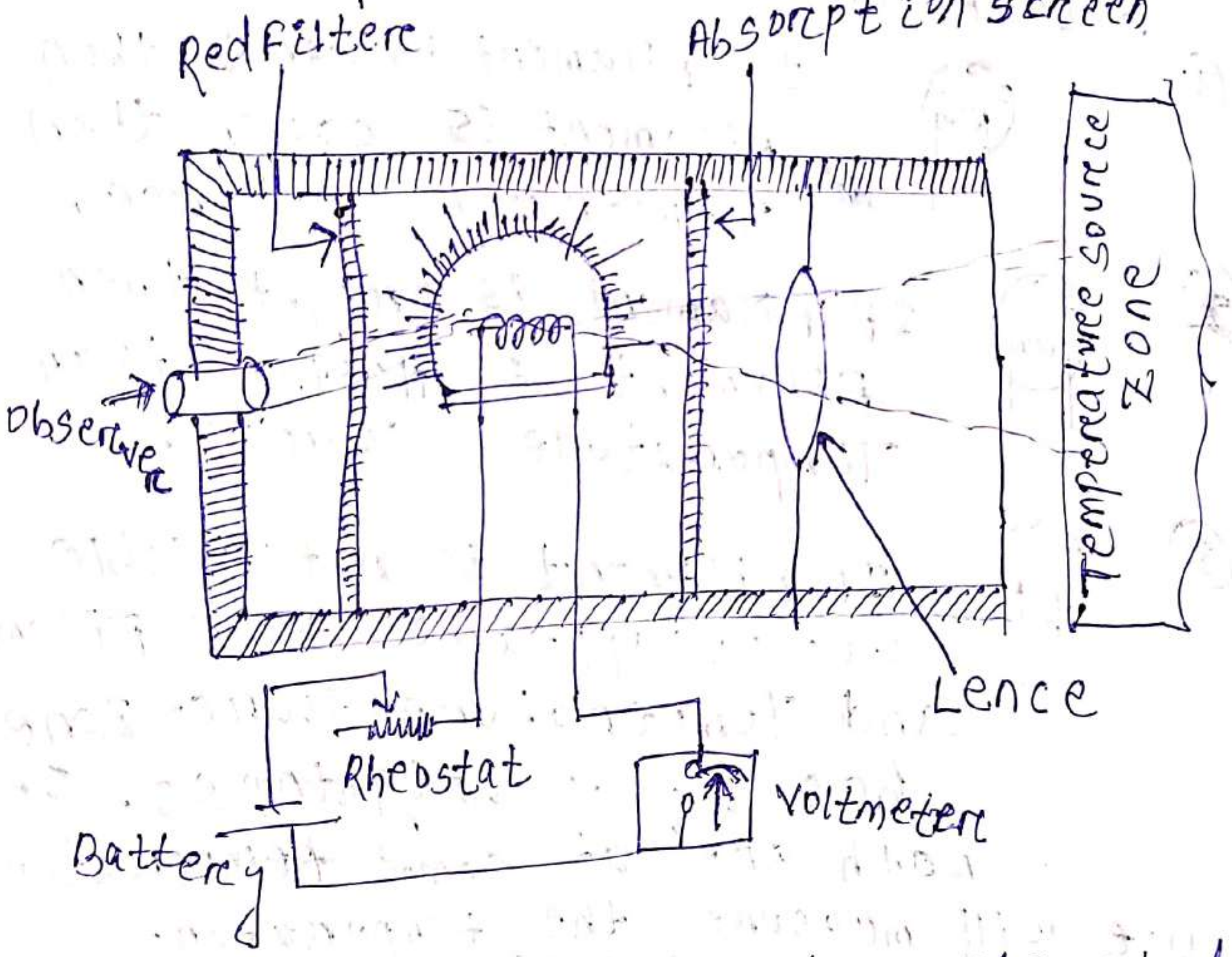
④ DSO can capture and store the electronic events.

⑤ DSO is widely used becaused of its advanced features like storage, display, fast trace rates and remarkable bandwidth.

DSO	Digital Voltmeter
↳ It shows the graphical representation of the signals for visual diagnosis and it helps to find out the unexpected voltage's source.	↳ It only records the voltage fluctuations which further require diagnosis.

OPTICAL PYROMETER :- (Disappearing Filament Type)

- It can measure temperature 700°c to 2500°c.
- It is also called Monochromatic brightness radiation Thermometer. By measuring the brightness in filament we can measure the temperature.



- Filament is connected to Rheostat and in other hand it is connected to voltmeter. voltmeter reading will change according to light in the filament. Due to supply (or) Battery connection Light energy is produced.
- From Temperature Source zone radiations are coming.

↳ Absorption screen well absorb the radiations from Temperature Zone.

↳ Red filter absorbs the Red Lights.

↳ Because of Lence Lights from temperature zone passing through it and light is focused at filament. So filament is very bright.

↳ observer can see 2 brightness at the filament one is brightness due to supply and another one is brightness due to radiations.

3 cases are available

①

If filament is dark then filament is cooler than Temperature Source.

②

If Filament is Bright then Filament is Hotter than Temperature source.

③

If filament is not visible i.e. Disappears then Filament and Temperature source zone has Equal brightness. i.e. Both are at same temperature.

we will measure the temperature according to brightness of the Filament.

↳ Let us assume the filament is at Dark color initially.

↳ After that we have to supply electricity supply by using Rheostat connection. So filament is brighter and by giving more current filament is more brighter than Temperature Zone.

↳ Again by giving more current filament Brightness is equal with Radiation Brightness and ~~a~~ Filament Disappeares, i.e. not Visible from observer side.

↳ whatever current we will supply by Rheostat adjusting that is measured by Voltmeter.

↳ whenever the bilament is disappearing we have to measure the supplying voltage that voltage will measure the temperature. change in voltage will measure the change in Temperature.

Applications :- ① It is used for measuring temperature of Molten metal.

② It is used to measure furnace temperature.

ADVANTAGES :- ⓘ Physical contact of the instrument is not required to measure temperature of the temperature source.

(ii) Accuracy is high ± 5°c.

(iii) Instrument is easy to operate.

(iv) The distance ~~a~~ between heat source and instrument does not matter.

~~DIS~~ LIMITATIONS :- ⓘ Temperature more than 700°c can only measured.

(ii) it is manually operated. It is cannot be used for continuous monitoring and controlling processes.

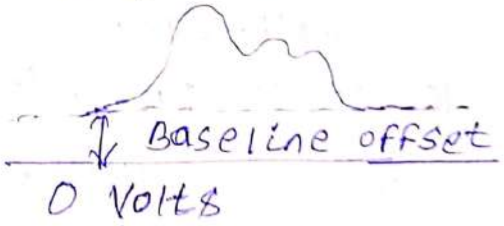
PULSE GENERATOR :-

- ↳ pulse generators are electronics test instruments that are used to generate pulses i.e. rectangular pulses.
- ↳ It is used to generate pulses that can stimulate Logic circuit.
- ↳ It is also used with an oscilloscope as the measuring device.
- ↳ The waveform displayed either at the output (or) at some specific points in the system under test.
- ↳ It provides both qualitative and quantitative information about the device under test.

Characteristics of pulse :-

① **BaseLine :-** It is referred to as the d.c. Level and is the line at which the pulse starts and finishes.

② **Base Line Drift/offset :-** The shift of this line from Zero Volts (or) the expected value.



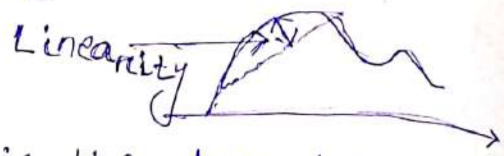
③ **Amplitude :-** It is measured from the baseline to the steady state pulse value.

④ **pulse rise time and fall time :-**

Rise Time is the time needed for the pulse to go from the 10% to 90% of its amplitude.

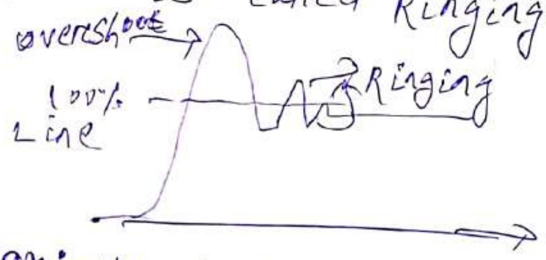
Fall Time is the time for the trailing edge to go from 90% to 10% of its amplitude.

⑤ Linearity :- It is the deviation of the edge from the straight line drawn through the pulse.



⑥ pulse preshoot :- It is the deviation prior to reaching the base line at the start of pulse.

⑦ Ringing :- positive and negative peak distortion of 100% Line of input excluding overshoot is called Ringing.



⑧ overshoot :- Maximum height.

⑨ settling Time :- Time period needed for pulse ringing to be within a specified percentage of the pulse amplitude.

⑩ pulse Droop (or) sag :- It is the fall in pulse amplitude with time.

⑪ Rounding :- It is the curvature of the pulse at the leading and trailing edge.

⑫ pulse width :- It is measured in units of time. It is the time between 50% points on the leading and trailing edge

⑬ pulse period :- It is the time between the equal points on the waveform.

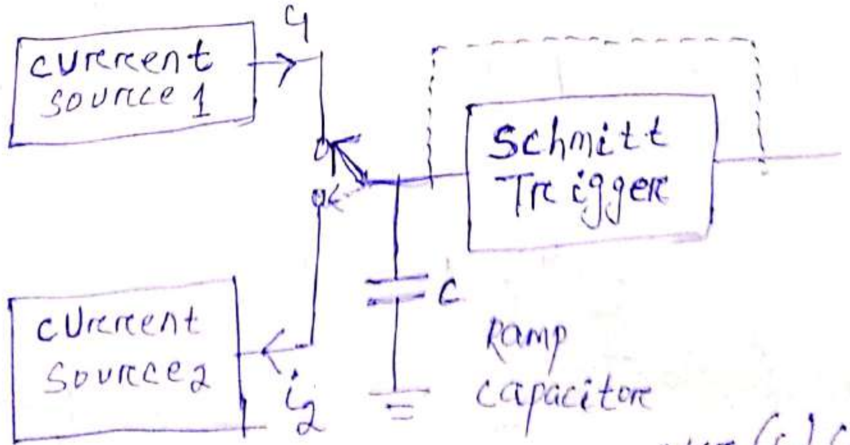
(14) Pulse Repetition Rate :- It determines how frequently pulse occurs.

(15) Duty cycle :- It is the ratio of pulse width to the pulse period.

(16) Pulse Jitter :- It is a measure of short term instability of one event with respect to another.

PULSE GENERATOR BLOCK DIAGRAM :-

- ↳ Frequency range of the instrument is covered in seven decade steps from 1 HZ to 10 MHZ with a linearly calibrated dial for adjustments on all ranges.
- ↳ The duty cycle can be varied from 25% to 15%.
- ↳ Two independent outputs available ① 600 Ω (Here rise time and fall time is 70ns at 30 Volt peak amplitude) ② 50 Ω (Here Rise time and fall time is 5ns at 5Volt peak Amplitude.)
- ↳ Free running generator (or) it can be synchronized with external signals.
- ↳ Trigger output pulses are also available.
- ↳



↳ i_1 is responsible for capacitor (c) charging, Capacitor (c) discharges through current source i_2.

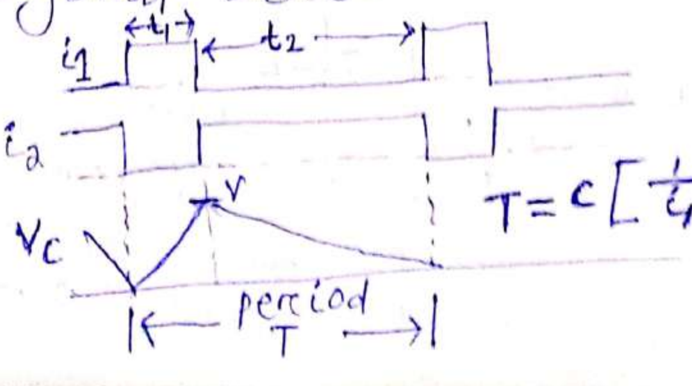
↳ Here we are having symmetry control that determines the ratio of two currents and ~~then~~ it determines Duty cycle of the output waveform.

↳ frequency Dial controls the sum of the two currents from the current sources.

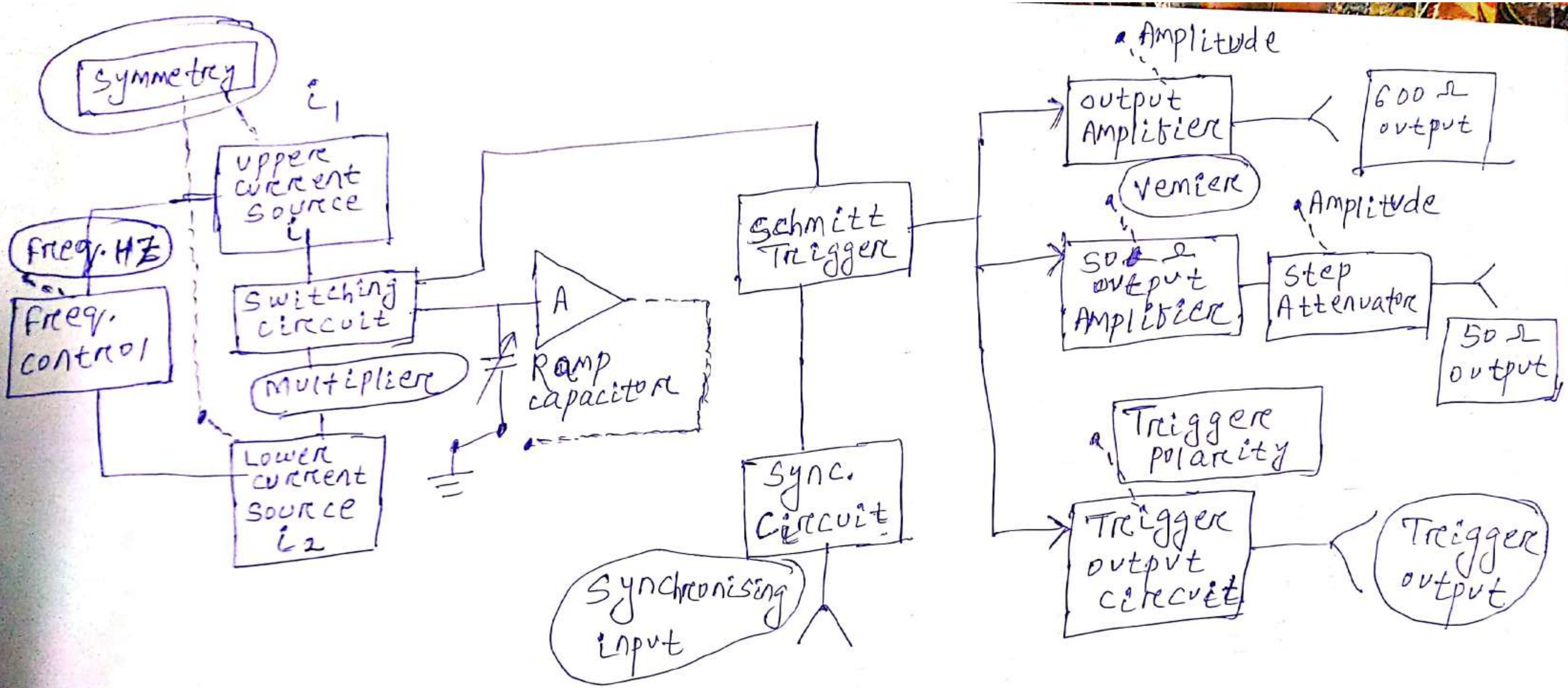
↳ multiplier selects the size of the ramp capacitor.

↳ frequency Dial and multiplier provides decade switching and a vernier control of the frequency of the output.

↳ upper current source that gives constant current to the Ramp capacitor and then capacitor is charged up and Ramp voltage increases linearly. when Ramp voltage increasing reaches the upper limit set by internal components then schmitt Trigger changes the state. so output is negative. Reverse current flows now and capacitor starts discharging. Now ramp voltage decreasing occurs when negative ramp reaches a predetermined ~~level~~ lower level, then schmitt Trigger switches back to the original state.



$$T = c\left[\frac{1}{i_1} + \frac{1}{i_2}\right]$$


Symmetry
i_1
upper current source
i
Freq. HZ
Freq. control
Switching circuit
Multiplier
Lower current source
i_2
A
Ramp capacitor
Schmitt Trigger
Sync. Circuit
Synchronising input
Amplitude
output Amplifier
600 Ω output
Vernier
Amplitude
50 Ω output Amplifier
Step Attenuator
50 Ω output
Trigger polarity
Trigger output circuit
Trigger output

↳ output of schmitt Trigger is given to Trigger output circuit, ~~50Ω~~ Amplifier of 50Ω output and Amplifier of 600Ω output.

↳ Trigger output differentiates the square wave output from the schmitt Trigger, inverts the resulting pulse and provides a positive triggering pulse.

↳ 50Ω output Amplifier has 2 control i.e. output attenuator and vernier control. The unit is provided by an internal supply that provides regulated voltage to all stages of the instrument.

↳ 600Ω output has only 1 control i.e. Amplitude control.

Date__________ Sitting - 1st

Regd. No. __________

Sub. Code & Name __________

Sem. & Branch __________

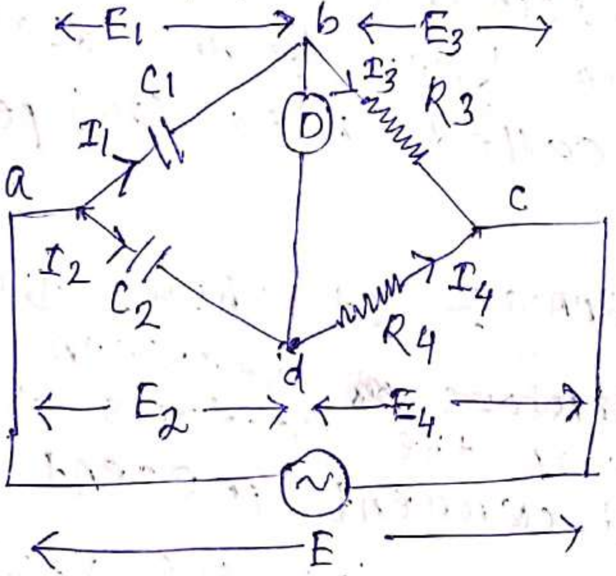
No. of Additionals used __________

Full Signature of Invigilator

DESAUTY'S BRIDGE :-

↳ It is used for the measurement of capacitance of a capacitor by comparing it with a standard capacitore.

↳ There are 4 arms in this bridge having 4 impedances Z_1, Z_2, Z_3, Z_4.



In arm a-b, $Z_1 = \frac{1}{jwC_1}$, In arm b-c, $Z_3 = R_3$,

In arm cd, $Z_4 = R_4$, In arm ad $Z_2 = \frac{1}{jwC_2}$

↳ The Bridge is at balance condition when the detector gives null deflection. That means potential difference ~~at~~ between point b and ~~at~~ d is zero. [Voltage drop across $Z_1 = Z_2 \Rightarrow E_1 = E_2$]

for Alternating current Bridge, the bridge balance condition is

$$\boxed{Z_1 Z_4 = Z_2 \cdot Z_3}$$

$$\Rightarrow \frac{1}{j\omega C_1} \cdot R_4 = \frac{1}{j\omega C_2} \cdot R_3$$

$$\Rightarrow \frac{C_1}{C_2} = \frac{R_4}{R_3} \Rightarrow \boxed{C_1 = C_2 \cdot \frac{R_4}{R_3}}$$

C_1 is unknown capacitance which value we want to measure.

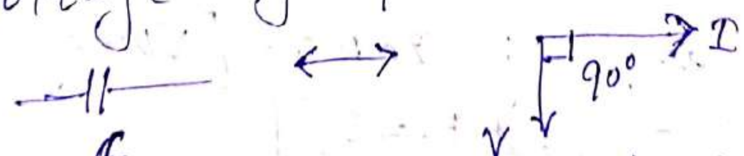
C_2 is standard (or) known capacitance which value already known by the user.

↳ De sauty Bridge is used to find the capacitance of those capacitor which are free from dielectric losses. That is called ideal (or) perfect capacitor.

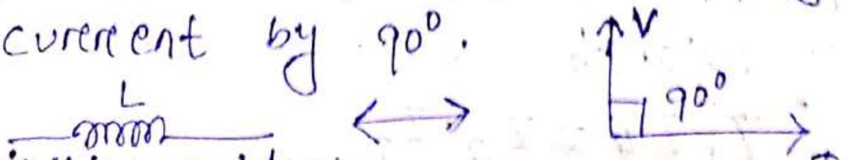
PHASOR DIAGRAM :- It shows the relationship between phasors (or) between the vectors of various voltage and current present in the circuit.

↳ For resistance (R), the voltage and current are in same phase with each other.

↳ For capacitor (C), the current leads voltage by 90°.



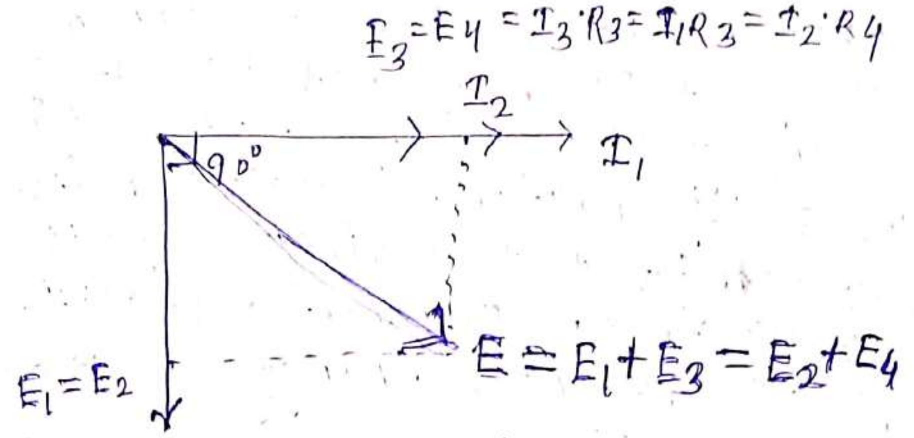
↳ For Inductor (L), The Voltage leads current by 90°.



Here in this Bridge,

$E_1 = \frac{I_1}{j\omega C_1}$, $E_2 = I_2/j\omega C_2$, $I_1 = I_3$ and $I_2 = I_4$

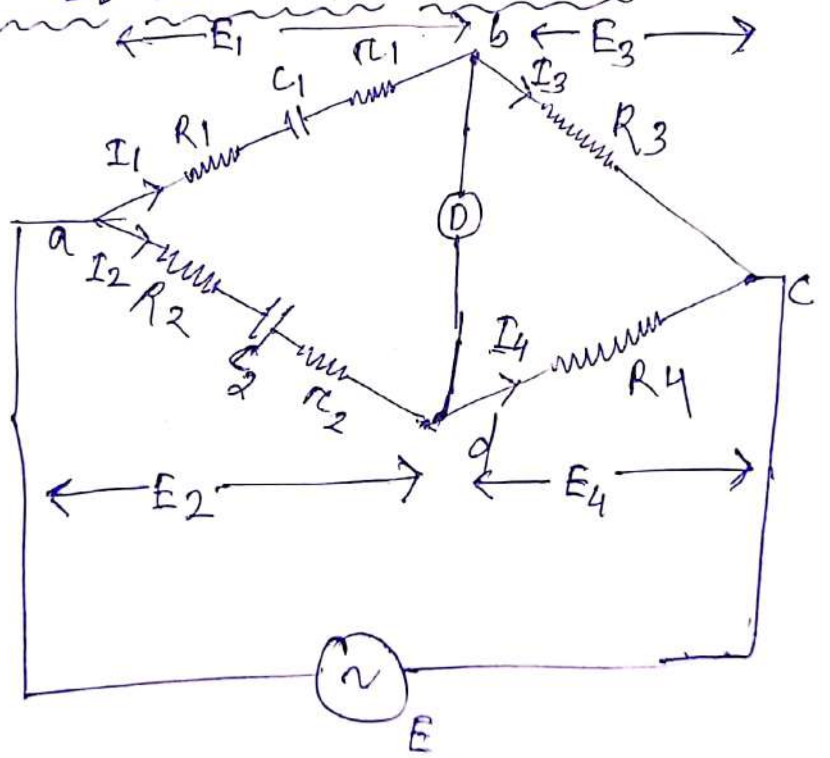
$E_1 = E_2$ and $E_3 = E_4$



$$\frac{I_1}{j\omega C_1} = \frac{I_2}{j\omega C_2}$$

↳ To measure ~~imperfect~~ capacitance of imperfect capacitor (or) Nonideal capacitor we use Modified De-sauty's bridge.

MODIFIED DE-SAUTY'S BRIDGE :-



↳ Here r_1, r_2 represents Loss component.

$Z_1 = R_1 + r_1 + \frac{1}{j\omega C_1}$, $Z_3 = R_3$

$Z_2 = R_2 + r_2 + \frac{1}{j\omega C_2}$, $Z_4 = R_4$

bridge balance condition is $Z_1 \cdot Z_4 = Z_2 \cdot Z_3$

By solving we will get

$$\boxed{\frac{C_1}{C_4} = \frac{R_4}{R_3} = \frac{R_2 + r_2}{R_1 + r_1}}$$

↳ Dissipation factor we can measure by using this bridge. It is defined as Tangent of Loss angle. It is also Reciprocal of quality factor. quality factor is figure of merit that defines quality (or) goodness of electrical component. quality factor gives how much energy is stored in the capacitor.

$D_1 = \tan\delta_1 = \omega C_1 R_1$, $D_2 = \tan\delta_2 = \omega C_2 R_2$

$$\boxed{D_2 - D_1 = \omega C_2 \left(\frac{R_1 R_4}{R_3} - R_2\right)}$$

—— x —— x —— x ——

MEASUREMENT OF 'Resistances' :-

① Low Resistance (R < 1Ω)

② Medium Resistance (R = 1Ω to 100KΩ)

③ High Resistance. (R > 100KΩ)

Low Resistance Examples :- Armature windings, Diode forward bias resistances, series field winding, compensation winding.

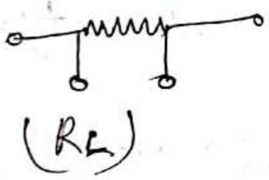
This Resistance having 4 terminals.

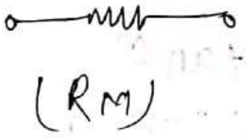
medium Resistance Examples :- potentiometer slide wire, shunt field winding resistance, etc.

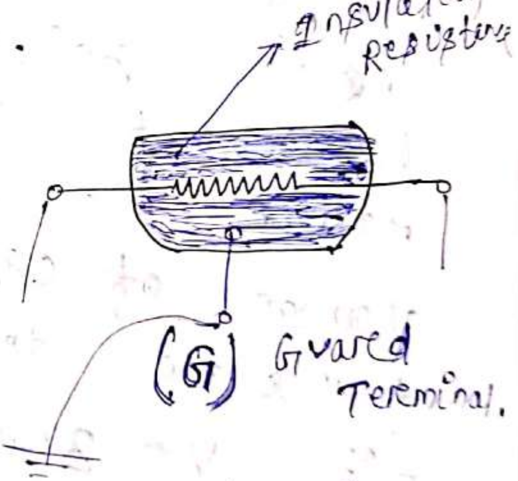
Md. Resistance having 2 terminals.

High Resistance Examples :- opamp i/p impedance, Diode Reverse Insulation resistances, Insulation Resistances. etc.

High Resistance having 3 terminals.







↳ Guard Terminal is used to avoid leakage current in the insulation Resistance.

when we connect the multimeter terminals we find the parallel combination of high resistance and Insulation Resistance. Before using it we use. Guard terminal.

↳ Low Resistance can be measured by Kelvin's double Bridge.

↳ Medium Resistance can be measured by

① wheat stone Bridge. (High Accurate)

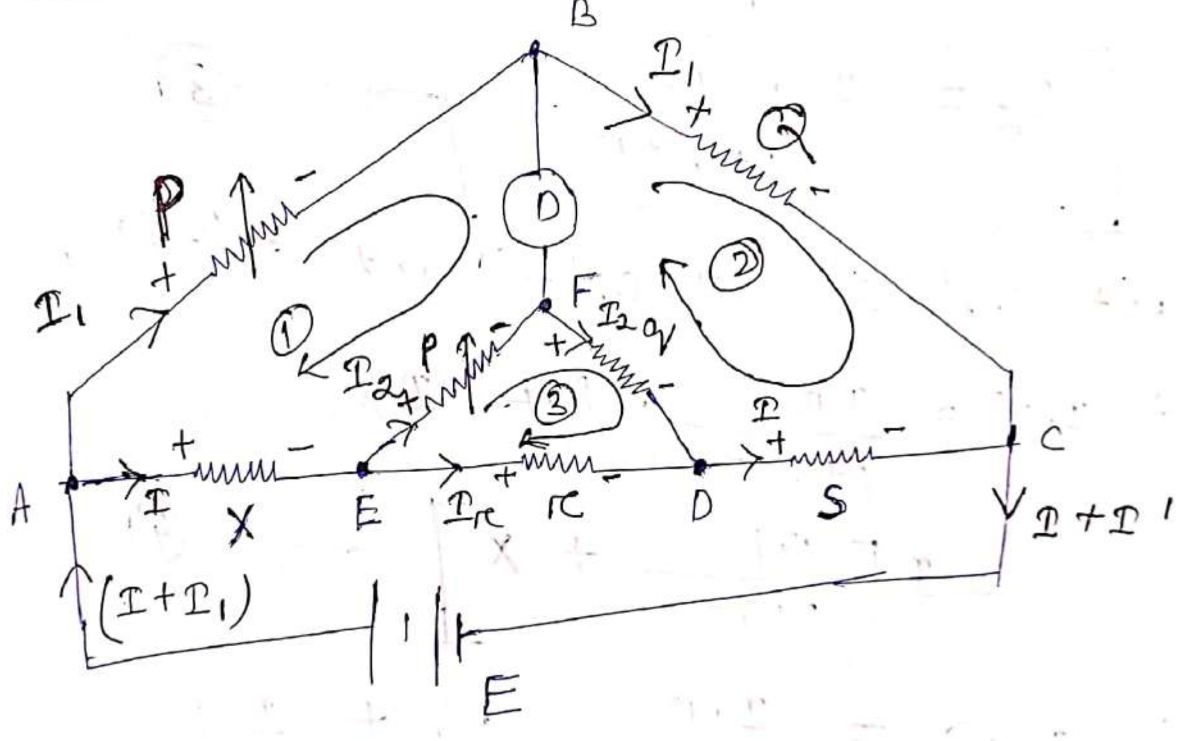
② V-A / A-V } method.

③ substitution method.
④ ohm meter. (Less accurate)

↳ High resistance can be measured by
① Megger.
② Loss of charge method. (High accurate)
③ Direct deflection method.
④ Mega ohm Bridge. (Less accurate)

MEASUREMENT of LOW RESISTANCE :-

Kelvin's Double Bridge :-



X: unknown low resistance.

P, Q, p, q, [redacted] : Bridge Resistor (or) known Resistor.

lead resistor.

r :- contact and lead

s :- standard Resistor.

Detector will detect 0 current means potential of 'B' = potential "F".

K.V.L. on Loop-1 :-

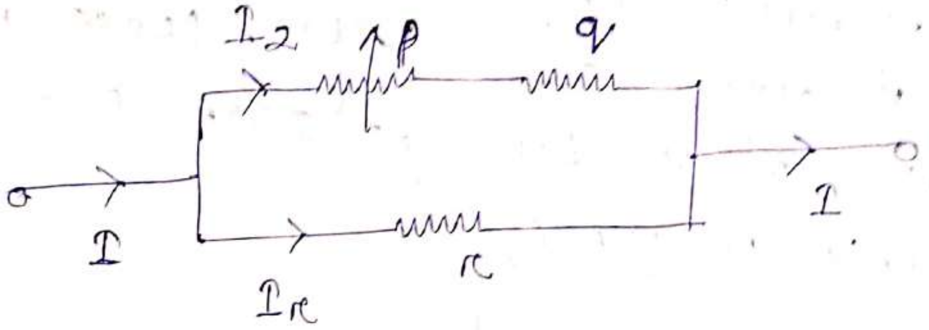
$$-I_1 \cdot P + I_2 \cdot p + IX = 0$$

$I_1 \cdot P = I_2 p + I \cdot X$ —— ①

K.V.L. eqⁿ on loop-2 :-

$-I_1 \cdot Q + IS + I_2 \cdot q = 0$

$\Rightarrow I_1 Q = I_2 q + IS$ —— ②



$$\boxed{I_2 = I \cdot \frac{r}{p+q+r}}$$ —— ③

put eqⁿ-③ in eqⁿ-① and eqⁿ-②,

$\Rightarrow I_1 \cdot P = \frac{I r}{p+q+r} \cdot p + I X$

$= I\left[\frac{r p}{p+q+r} + X\right]$ —— ④

$\Rightarrow I_1 \cdot Q = \frac{I \cdot r}{p+q+r} \cdot q + I S$

$= I\left[\frac{r \cdot q}{p+q+r} + S\right]$ —— ⑤

eqⁿ-④ ÷ eqⁿ-⑤,

$$\Rightarrow \frac{P}{Q} = \frac{\left[\frac{r p}{p+q+r} + X\right]}{\left[\frac{r \cdot q}{p+q+r} + S\right]}$$

$$\Rightarrow \frac{P}{Q}\left[\frac{r\cdot q}{p+q+r}+S\right]=\frac{r\cdot p}{p+q+r}+X$$

$$\Rightarrow X=\frac{P}{Q}\cdot S+\frac{P}{Q}\cdot\frac{rq}{p+q+r}-\frac{r\cdot p}{p+q+r}$$

$$\Rightarrow \boxed{X=\frac{P}{Q}\cdot S+\frac{r\cdot q}{p+q+r}\left[\frac{P}{Q}-\frac{p}{q}\right]}$$

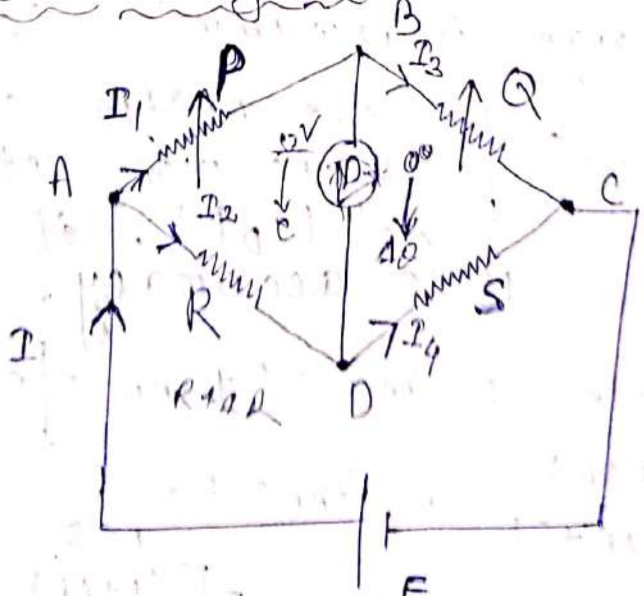
↳ By using Kelvin's double Bridge we can also measure medium Resistance by ~~the~~ ~~cond~~ the condition, making ~~putting~~

$$\boxed{\frac{P}{Q}=\frac{p}{q}}$$

↳ In Kelvin's Double bridge both wheatstone bridge and Kelvin bridge is available. so it is called double ~~bridg~~ bridge.

Measurement of Medium Resistance :-

① wheatstone Bridge :-



R: unknown medium resistance.

under Balanced condition,
voltage drop across AB = voltage drop across AD.

$$\Rightarrow I_1 \cdot P = I_2 \cdot R$$

$$\Rightarrow \frac{I_1}{I_2} = \frac{R}{P} \quad \text{——} ①$$

voltage drop across BC = voltage drop across DC

$$\Rightarrow I_3 Q = I_4 \cdot S$$

$$\Rightarrow \frac{I_3}{I_4} = \frac{S}{Q} \quad \text{——} ②$$

$$\Rightarrow \frac{R}{P} = \frac{S}{Q} \Rightarrow \boxed{R = \frac{P}{Q} \cdot S}$$

sensitivity (S) :- There are 2 sensitivity, in wheatstone bridge, ① Detector sensitivity ② Bridge sensitivity.

① Detector sensitivity :- $S_D = \frac{\text{change in deflection}}{\text{change in potential difference}}$

$$\boxed{S_D = \frac{\Delta\theta}{e}}$$

② Bridge sensitivity :-

$$S_B = \frac{\text{change in deflection}}{\text{unit change in Resistance}} = \frac{\Delta\theta}{(\Delta R/R)}$$

$$\Rightarrow \boxed{S_B = \frac{S_D \cdot e}{(\Delta R/R)}}$$

The Bridge sensitivity depens upon detector sensitivity As $(S_D\uparrow)$, we may not loose accuracy.

$e = V_B - V_D$

$V_B = E - V_{AB}$

$V_D = E - V_{AD}$

$$\Rightarrow e = E - V_{AB} - E + V_{AD} \Rightarrow \boxed{e = V_{AD} - V_{AB}}$$

$$V_{AD} = E \cdot \frac{(R+\Delta R)}{(R+\Delta R+S)}, \quad V_{AB} = E \cdot \frac{P}{P+Q}$$

$\frac{R}{Q} =$ ~~P/S~~ ⇒ $Q/P =$

$$\Rightarrow e = E\left[\underbrace{\frac{(R+\Delta R)}{(R+\Delta R+S)}}_{V_{AD}} - \underbrace{\frac{P}{(P+Q)}}_{V_{AB}}\right]$$

$$\Rightarrow P/Q = R/S \Rightarrow Q/P + 1 = S/R + 1$$

$$\Rightarrow \frac{P+Q}{P} = R+S/R$$

$$\Rightarrow P/P+Q = \frac{R}{R+S}$$

$$\Rightarrow e = E\left[\frac{(R+\Delta R)}{(R+\Delta R+S)} - \frac{R}{R+S}\right]$$

$$\Rightarrow E = E\left[\frac{(R+\Delta R)(R+S) - R(R+\Delta R+S)}{(R+\Delta R+S)(R+S)}\right]$$

$$= E\left[\frac{\cancel{R^2} + \cancel{RS} + \cancel{\Delta R\cdot R} + \Delta R\cdot S - \cancel{R^2} - \cancel{R\cdot\Delta R} - \cancel{R\cdot S}}{(R+\Delta R+S)(R+S)}\right]$$

$$= E\left[\frac{\Delta R\cdot S}{(R+S)^2 + \Delta R(R+S)}\right]$$

compare to $(R+S)^2$, $\Delta R(R+S)$ is negligible,

$$\Rightarrow \boxed{e = E\cdot\frac{\Delta R\cdot S}{(R+S)^2}}$$

$$\Rightarrow S_B = \frac{S_D\cdot e}{(\Delta R/R)} = \frac{S_D\cdot\frac{E\cdot\Delta R\cdot S}{(R+S)^2}}{(\Delta R/R)}$$

$$\Rightarrow S_B = \frac{S_D\cdot E\cdot R\cdot S}{(R+S)^2} = \frac{S_D\cdot E\cdot R\cdot S/RS}{\frac{(R+S)^2}{RS}}$$

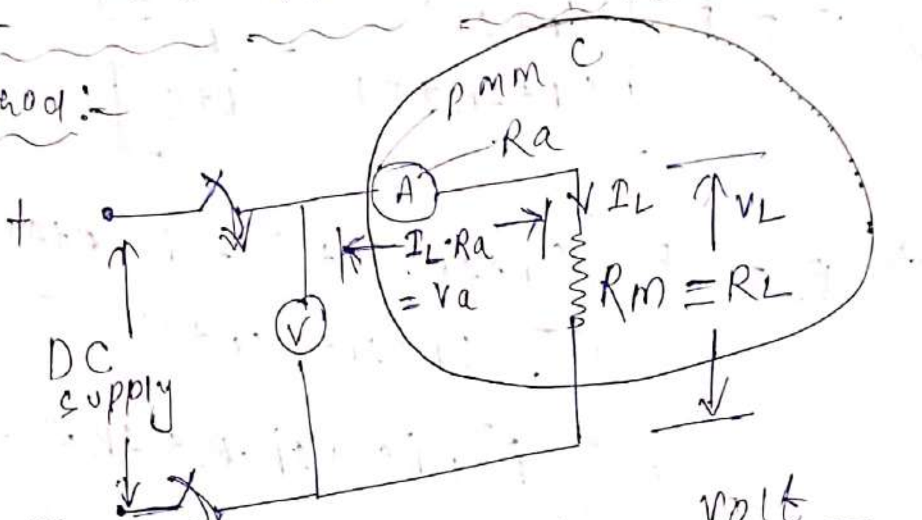
$$\Rightarrow \boxed{S_B = \frac{S_D\cdot E}{\left(\frac{R}{S} + \frac{S}{R} + 2\right)}}$$

Maximum Bridge sensitivity, when $\frac{R}{S} = 1$, $S/R = 1$

$$\boxed{S_{B\,max} = \frac{S_D \cdot E}{4}}$$

② Ammeter - voltmeter method (OR) voltmeter - Ammeter method :-

ⓐ V - A method :-



$$(R_m)_t = \frac{V_L}{I_L} \quad \frac{\text{volt}}{\text{Ammeter}}, \quad (R_m)_m = \frac{\text{volt}}{\text{Ammeter}}$$

$$= \frac{(V_L + V_a)}{I_L}$$

$$= \frac{V_L}{I_L} + \frac{V_a \rightarrow I_L R_a}{I_L}$$

$$\Rightarrow \boxed{R_m = R_t + R_a}$$

conclusion: ① In V-A method for the measurement of medium Resistance , measure value is greater than True value. ($R_m > R_t$) error bcz. of ammeter.

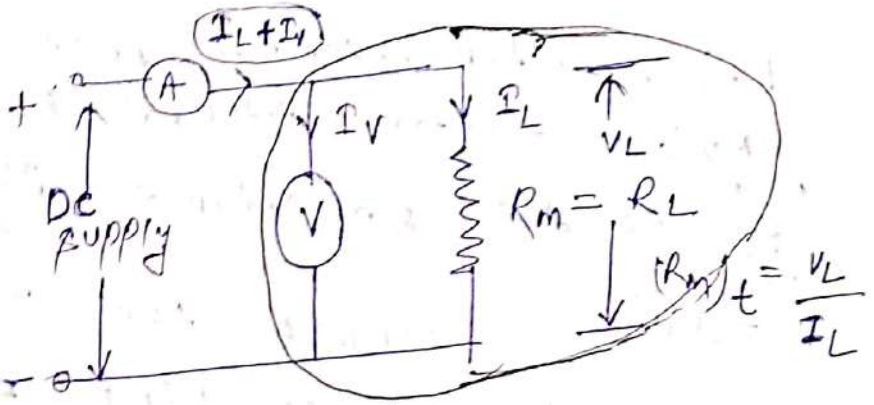
② In V-A method the best suitable for the

③ The V-A method measurement of high Resistance in the medium Range. so that the % error is monimum.

$$\% \text{ error} = \frac{\text{Measure value} - \text{True value}}{\text{True value}} \times 100$$

$$\downarrow \% \text{ error} = \frac{R_a}{(\uparrow R_m \text{ (or) } R_L)} \times 100$$

(b) A-V method:-



$$(R_m)_{meas} = \frac{Volt}{Ammeter} \Rightarrow (R_m)_m = \frac{V_L}{(I_L + I_V)}$$

$$\Rightarrow (R_m)_m = \frac{V_L}{\frac{V_L}{R_L} + \frac{V_L}{R_V}} \Rightarrow (R_m)_m = \frac{1}{\frac{1}{R_L}\left(1 + \frac{R_L}{R_V}\right)}$$

$$\Rightarrow (R_m)_m = \frac{R_L}{\left(1 + \frac{R_L}{R_V}\right)} \Rightarrow (R_m)_m + \frac{(R_m)_m \cdot R_L}{R_V} = R_L$$

$$\Rightarrow \frac{(R_m)_m - R_L}{R_L} = \frac{-(R_m)_m}{R_V} \cancel{\times 100}$$

$$\Rightarrow 100 \times \underbrace{\left(\frac{(R_m)_m - R_L}{R_L}\right)}_{\%\,error} = -\frac{(R_m)_m}{R_V} \times 100$$

$$\boxed{(R_L \downarrow)}$$

conclusions:-

① measured value ~~of~~ is less than True value.

② In A-V method the error bcz of voltmeter.

③ The AV method is best suitable of resistance in medium low measurement range.

NOTE:- In both the methods the error bcz of always load side of the instrument.

Equate the error in both the methods,

$$R_a / R_L = R_L / R_V \Rightarrow \boxed{R_L = \sqrt{R_a \cdot R_V}}$$

R_a :- Ammeter internal Resistance

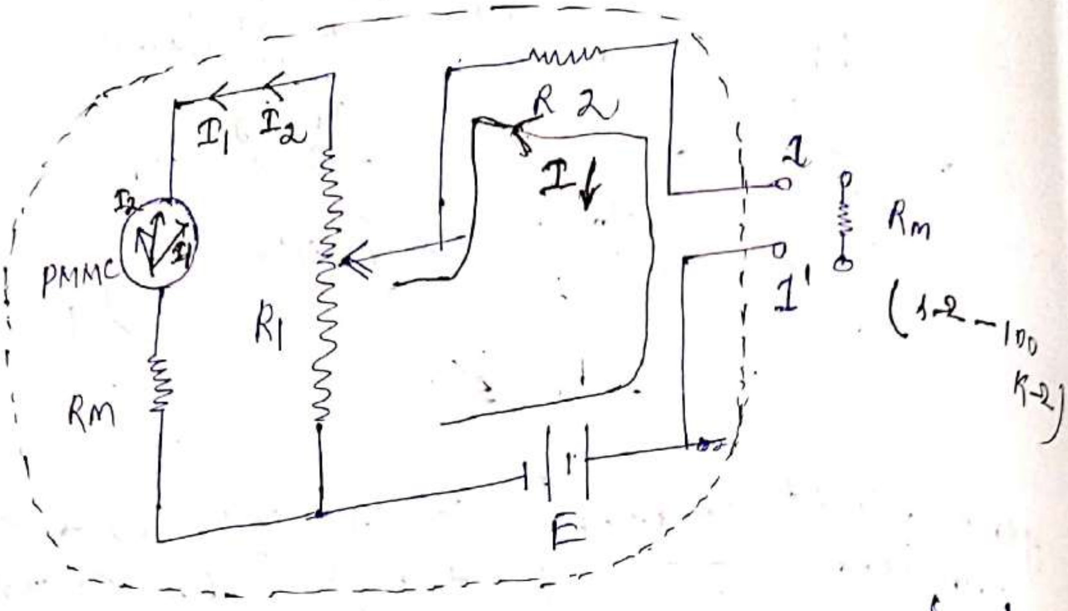
R_v :- voltmeter internal Resistance.

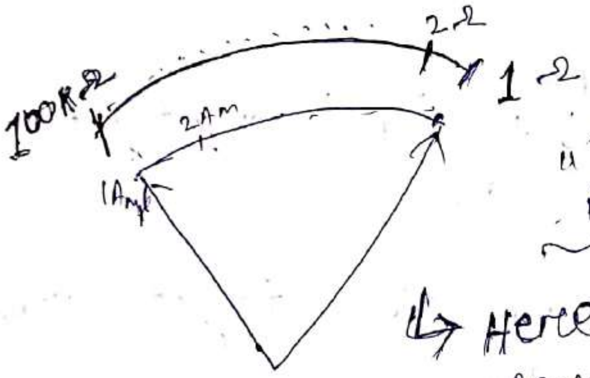
'R_L' is the Resistance if we connect it across the load to measure its value then we find equal % error in both the methods.

$= \sqrt{R_a \cdot R_v}$

— x —

④ Ohm meter :-





I min means "Rm" is max. and I max means "Rm" is minimum.

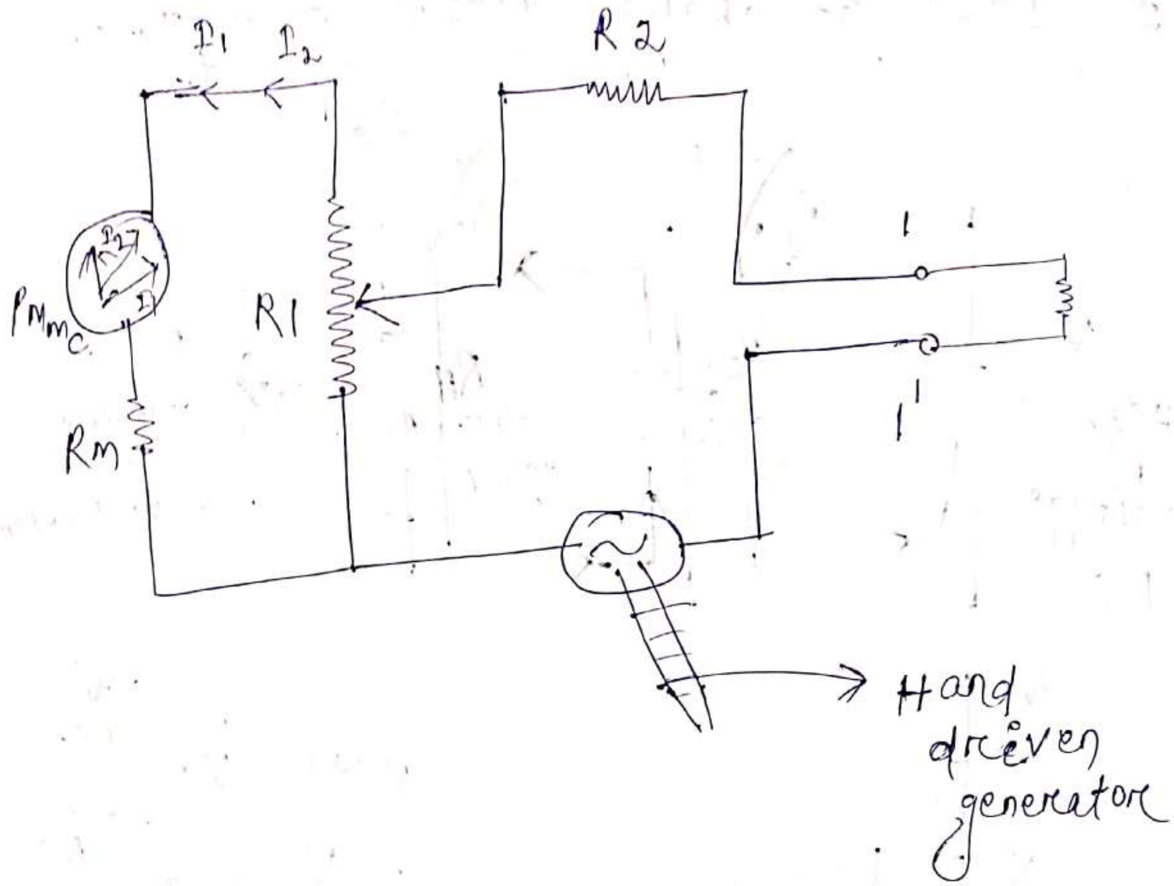
↳ Here the resistance scale is Reverse scale.

↳ It is suitable for measurement of medium Resistance.

If high Resistance will be placed the E is small so I will not circulate.

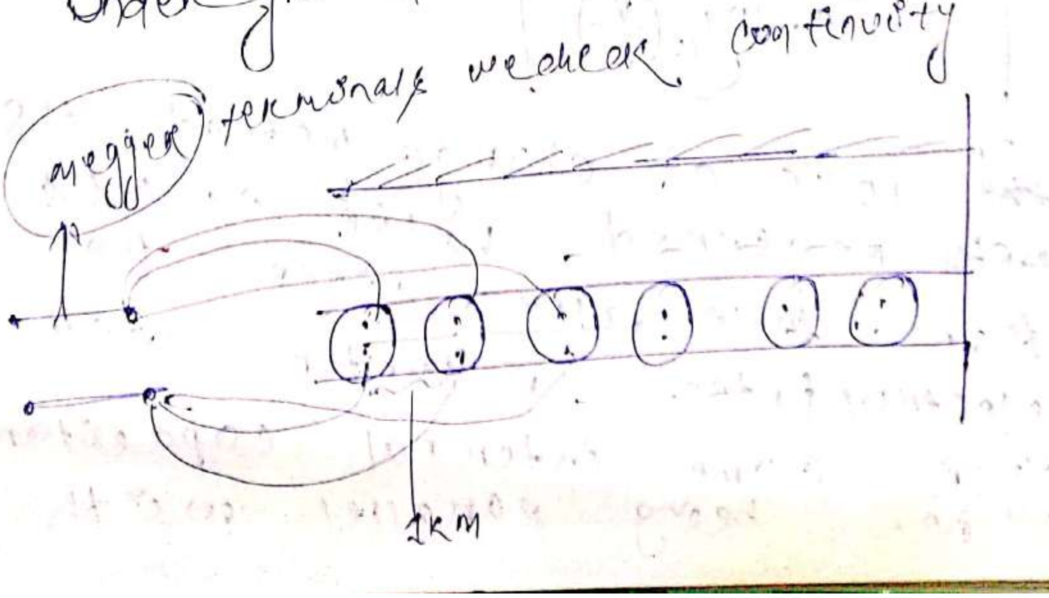
Measurement of High Resistance:-

① Meggere :- By replacing the battery with Hand driven generator, we can measure high

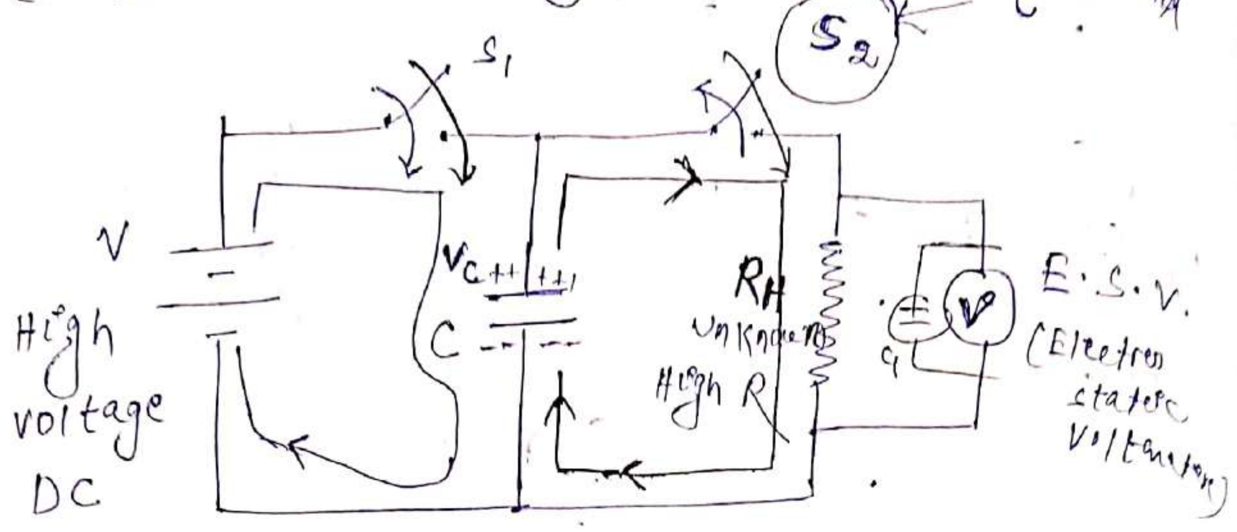


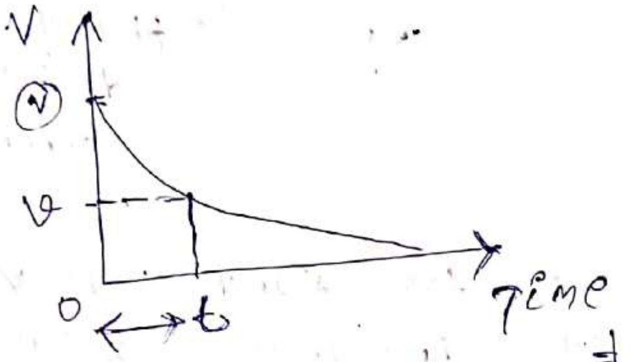
Resistance. since the Hand drueven generator will produce more voltage compare to battery so that it is sufficient ~~at~~ to dreive the current in the battery.

↳ The megger is best suitable to check the continuity in case of underground cables.



② Loss of charge Method :-





$$v(t) = V \cdot e^{\frac{-t}{RC}}$$

$$\Rightarrow \frac{v}{V} = e^{-t/RC}$$

$$\Rightarrow \ln\left(\frac{v}{V}\right) = \frac{-t}{RC}$$

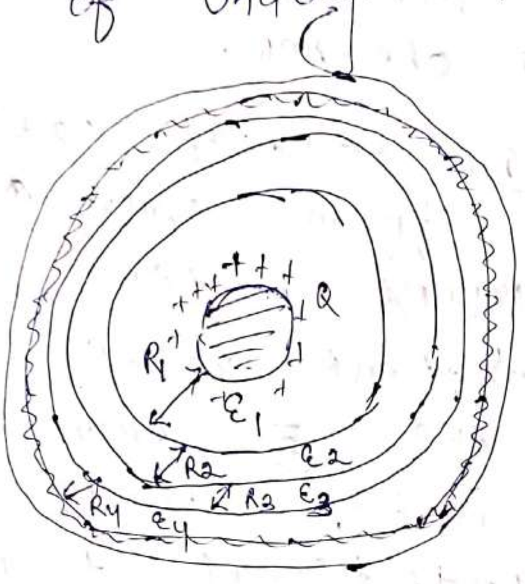
$$\Rightarrow \ln\left(\frac{V}{v}\right) = \frac{t}{RC} \Rightarrow \boxed{R = \frac{t}{C \cdot \ln\left(\frac{V}{v}\right)}}$$

(OR)

$$\Rightarrow \boxed{R = \frac{0.434\,t}{C \cdot \log_{10}\left(\frac{V}{v}\right)}}$$

→ ~~the~~ In loss of charge method, the ~~meth~~ measured value is less than true value since the electrostatic voltmeter will offer some internal capacitance i.e. being parallel with th actual capacitance so that net ~~capca~~ capacitance value will increase and ~~R~~ measured (R) decreases.

↳ The loss of charge method is best suitable for the measurement of insulation Resistance in case of underground cables.



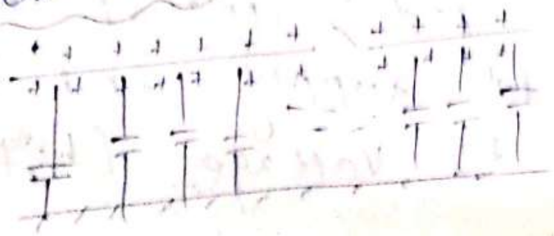
$$\oiint_S \vec{E}\cdot d\vec{S} = \frac{1}{\epsilon_0}\cdot Q$$

$$\vec{E}\cdot 2\pi r \times 1 = \frac{1}{\epsilon_0}\cdot Q$$

$$\Rightarrow \vec{E}_0 = \frac{Q}{2\pi\epsilon_0\cdot r} \Rightarrow \boxed{E_0 \propto \frac{1}{r}}$$

↳

Train Line:



Here +ve charge on surface of core and on metal sheath minimum charges. so it acts as a capacitor. So no need to provide an extra cap. in the M/M by loss of charge method and also in core high dc is available so no need of extra supply. so here use of this method is cheaper.

In coaxial cable as the distance from core ↑, the insulation layers radius and dielectric constant value decreases because as the E from core surface to metal sheath is inversely propotional to radial distance so it actual dales at distant place. So no need of providing thick insulation of high dielectric at outer levels.

Hence $R_1 > R_2 > R_3 \cdots$

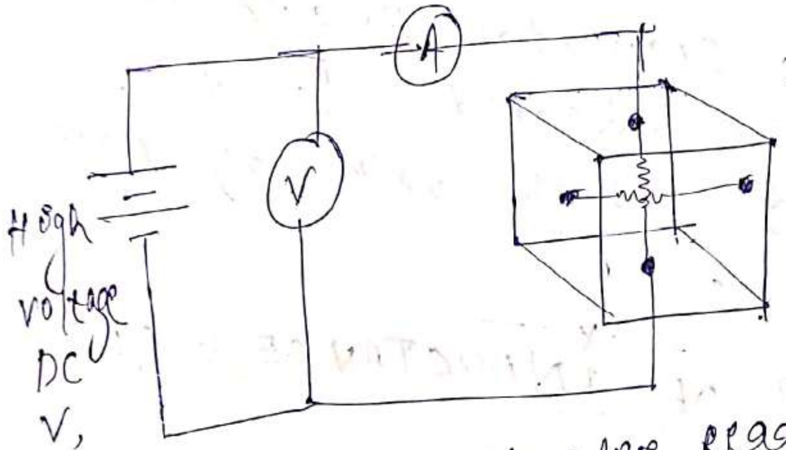
$\epsilon_1 > \epsilon_2 > \epsilon_3 \cdots$

→ Loss of charge method is costly except in this case because we have to get special connection of very high dc supply and to store the dc voltage (high value) capacitor reqd is very costly and E.S.C. also itself is costly.

③ Direct Deflection Method :-

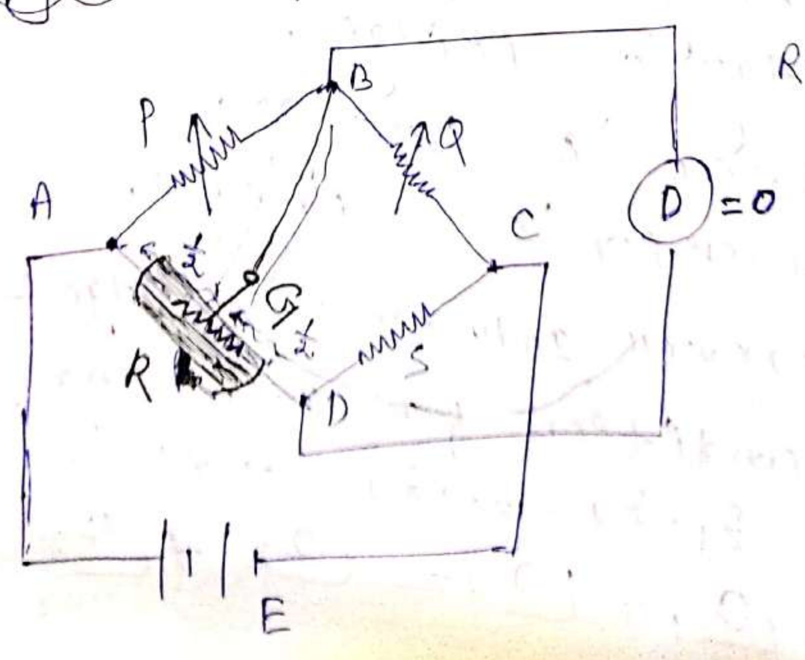
↳ This method is best suitable for the measurement of Resistivity. (ρ)

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



$$R = \frac{\text{Voltmeter Reading}}{\text{Ammeter Reading}}$$

④ Mega ohm Bridge :-



$R = \frac{P}{Q} \cdot S$

Here High Resistance connected.
'A' terminal connected to 'B' terminal
'P' is small and 'Q' is small. ½ of
High Resistances are connected
in parallel with pr and Qr.
so Resultant Resistance is
pq (small) || ½ high Resistance
= small Resistance

so effect of Insulator Resistance
can ~~not~~ not be affected to the
calculation of high value of Resistance (RH).

imp

MEASUREMENT OF INDUCTANCE :- (L)

AC Bridges.

① Maxwell's Inductance Bridge :-

② Maxwell's Inductance - capacitance Bridge.

③ Hay's Bridge.

④ Owen's Bridge.

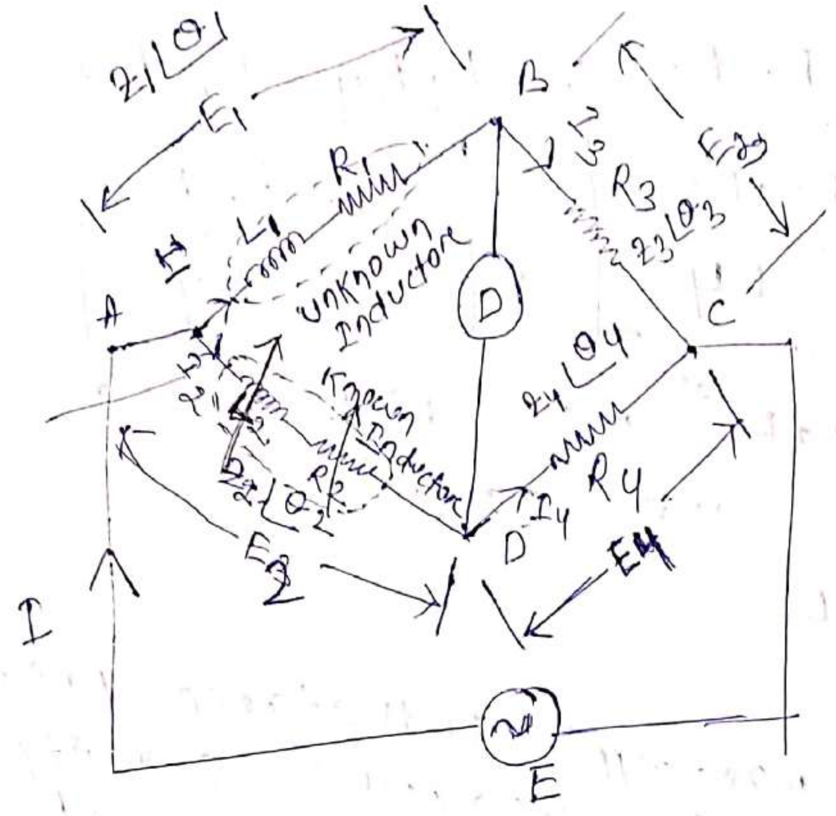
⑤ Anderson's Bridge.

① Maxwell Inductance Bridge :-

The condition for balancing,

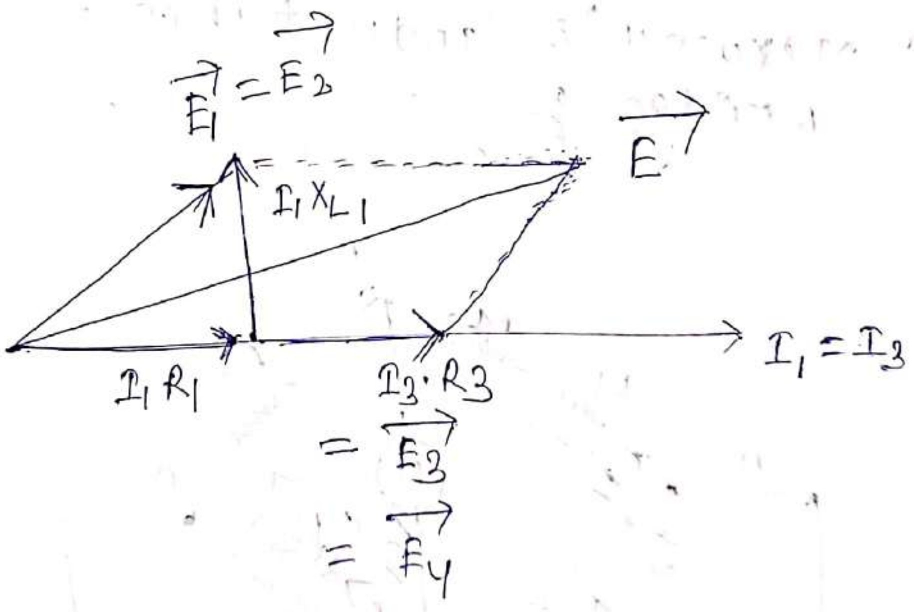
$$Z_1 \cdot Z_4 = Z_2 \cdot Z_3 \text{ (and)}$$

$$\angle\theta_1 + \angle\theta_4 = \angle\theta_2 + \angle\theta_3$$



$\vec{E} = \vec{E_1} + \vec{E_3}$ (or) $\vec{E_2} + \vec{E_4}$

phasor Diagram : (imp) 2 mark



$Z_1 \cdot Z_4 = Z_2 \cdot Z_3$

$\Rightarrow (R_1 + j\omega L_1)(R_4) = (R_2 + j\omega L_2)(R_3)$

$\Rightarrow R_1 R_4 + j\omega L_1 R_4 = R_2 R_3 + j\omega L_2 R_3$

comparing two sides we get.

$R_1 R_4 = R_2 R_3$, $L_1 R_4 = L_2 R_3$

$\Rightarrow \boxed{R_1 = \frac{R_2 \cdot R_3}{R_4}}$, $\boxed{L_1 = \frac{L_2 R_3}{R_4}}$

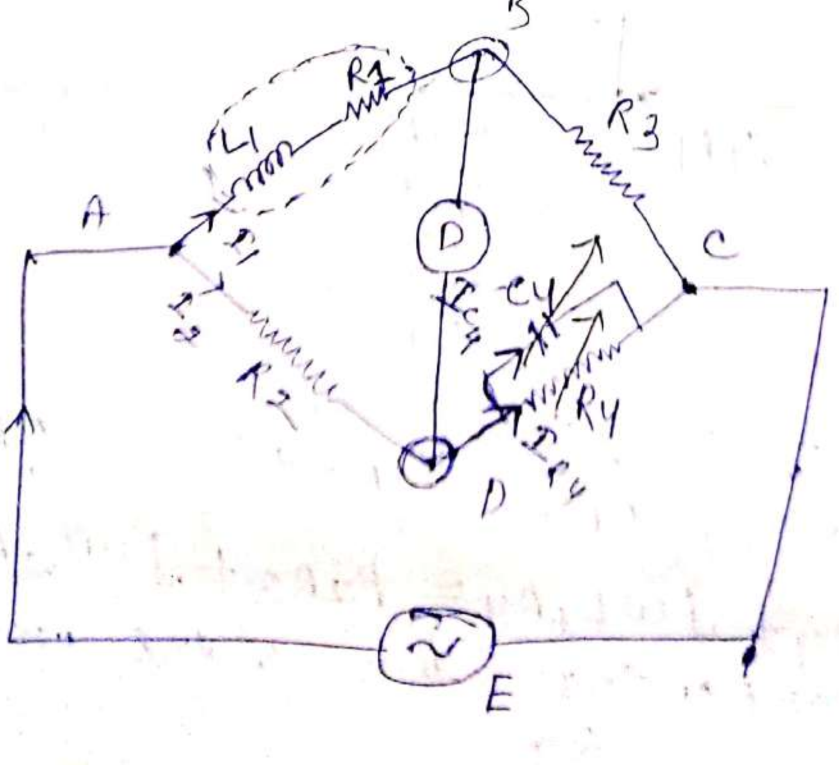
"R_2 and L_2" are different in both the cases.

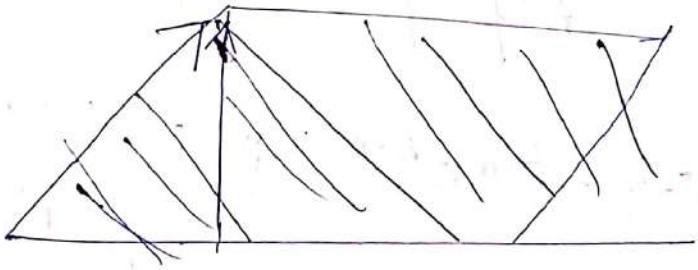
$Q = \frac{\omega L}{R}$

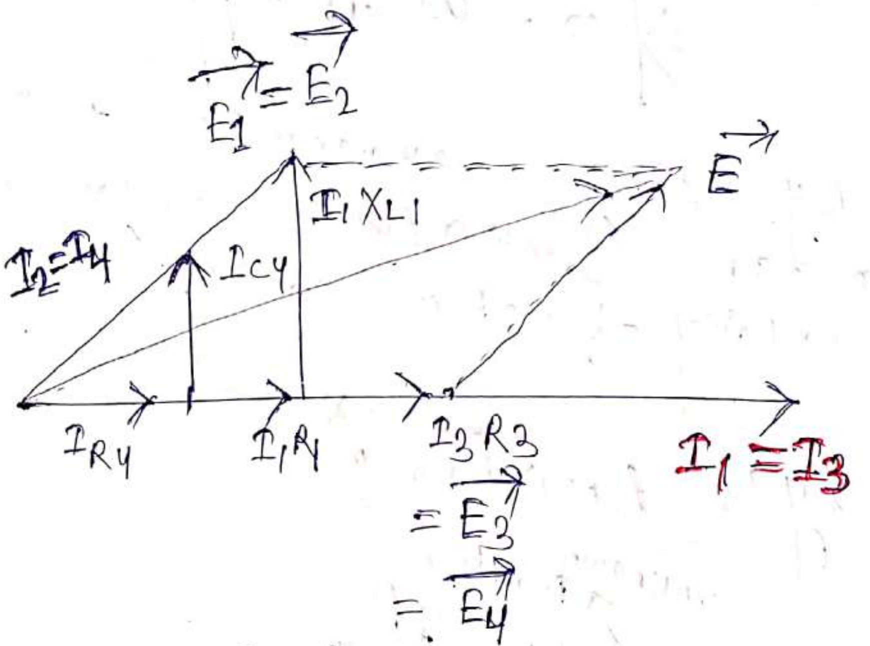
↳ By using maxwell's Inductance Bridge we can not measure quality factor since we can not bring ~~this~~ this bridge to resonance condⁿ. (No capacitor present)

——x——

② maxwell's Inductance - Capacitance Bridge :







$$Z_1 \cdot Z_4 = Z_2 \cdot Z_3$$

$$\Rightarrow (R_1 + j\omega L_1)\left(R_4 \parallel \frac{1}{j\omega C_4}\right) = R_2 \cdot R_3$$

$$\Rightarrow (R_1 + j\omega L_1)\left(\frac{R_4 \cdot \frac{1}{j\omega C_4}}{R_4 + \frac{1}{j\omega C_4}}\right) = R_2 \cdot R_3$$

$$\Rightarrow (R_1 + j\omega L_1)\left(\frac{\frac{R_4}{j\omega C_4}}{\frac{R_4 \cdot j\omega C_4 + 1}{j\omega C_4}}\right) = R_2 \cdot R_3$$

$$\Rightarrow (R_1 + j\omega L_1)\left(\frac{R_4}{1 + j\omega R_4 C_4}\right) = R_2 \cdot R_3$$

comparing both sides we get

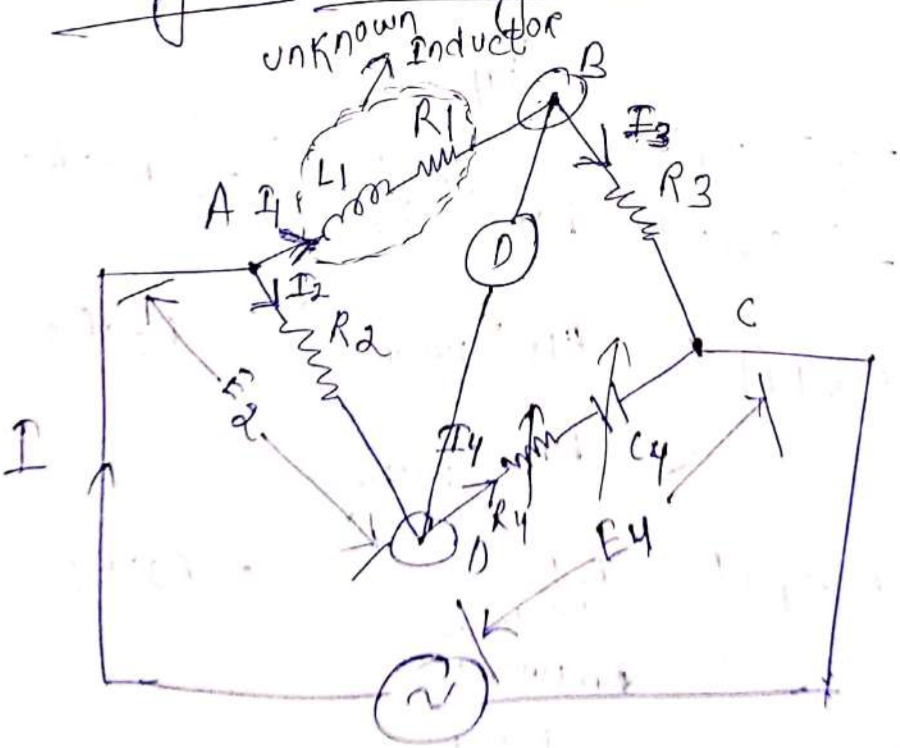
$$\Rightarrow \boxed{R_1 = \frac{R_2 \cdot R_3}{R_4}} \quad \text{and} \quad \boxed{L_1 = R_2 R_3 C_4}$$

$$\text{quality-factor } (Q) = \frac{\omega L_1}{R_1}$$

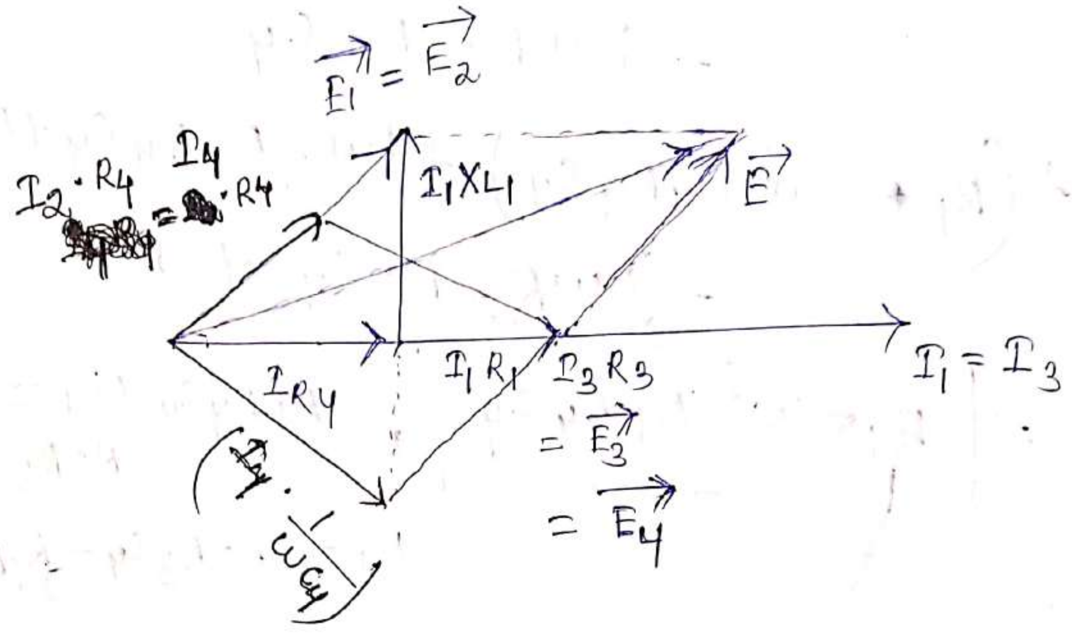
$$\Rightarrow \boxed{Q = \omega C_4 \cdot R_4}$$

↳ By using maxwell's Bridge we can measure only low quality-factor coil. (Q<10)

Hay's Bridge :-



$$\boxed{E_4 = V_{R4} + V_{C4}}$$



$$Z_1 \cdot Z_4 = Z_2 \cdot Z_3$$

$$\Rightarrow (R_1 + j\omega L_1)\left(R_4 + \frac{1}{j\omega C_4}\right) = R_2 R_3$$

$$\Rightarrow R_1 R_4 + \frac{R_1}{j\omega C_4} + j\omega L_1 R_4 + \frac{\omega L_1}{\omega C_4} = R_2 R_3$$

$$\Rightarrow \left(R_1 R_4 + \frac{L_1}{C_4}\right) + j\left(\omega L_1 R_4 - \frac{R_1}{\omega C_4}\right) = R_2 R_3$$

comparing both the sides we get

$$R_1 R_4 + \frac{L_1}{C_4} = R_2 R_3 \quad , \quad \omega L_1 R_4 = \frac{R_1}{\omega C_4}$$

$$\boxed{R_1 = \frac{\omega^2 C_4^2 R_2 \cdot R_3 \cdot R_4}{1 + \omega^2 C_4^2 \cdot R_4^2}} \quad \boxed{L_1 = \frac{C_4 R_2 R_3}{1 + \omega^2 C_4^2 \cdot R_4^2}}$$

$$\Rightarrow (R_1 + j\omega L_1)\left(\frac{j\omega C_4 R_4 + 1}{j\omega C_4}\right) = R_2 R_3$$

$$\Rightarrow (R_1 + j\omega L_1)(1 + j\omega R_4 C_4) = j\omega R_2 R_3 C_4$$

$$\Rightarrow R_1 + j\omega R_1 R_4 C_4 + j\omega L_1 - \omega^2 L_1 R_4 C_4 = j\omega R_2 R_3 C_4$$

$$\Rightarrow \left(R_1 + - \omega^2 L_1 R_4 C_4\right) + j\omega\left(R_1 R_4 C_4 + L_1\right) = j\omega R_2 R_3 C_4 + 0$$

$$\Rightarrow \boxed{R_1 = \omega^2 L_1 R_4 C_4}, \quad R_1 R_4 C_4 + L_1 = R_2 R_3 C_4$$

$$L_1 = R_2 R_3 C_4 - R_1 R_4 C_4$$

$$\Rightarrow L_1 = R_2 R_3 C_4 - \omega^2 L_1 R_4 C_4 \cdot R_4 C_4$$

$$\Rightarrow L_1 = R_2 R_3 C_4 - \omega^2 C_4^2 \cdot R_4^2 \cdot L_1$$

$$\Rightarrow L_1 + \omega^2 C_4^2 \cdot R_4^2 \cdot L_1 = R_2 \cdot R_3 \cdot C_4$$

$$\Rightarrow L_1\left(1 + \omega^2 \cdot C_4^2 \cdot R_4^2\right) = R_2 \cdot R_3 \cdot C_4$$

$$\Rightarrow \boxed{L_1 = \frac{R_2 R_3 C_4}{1 + \omega^2 \cdot C_4^2 \cdot R_4^2}}$$

put it in the formula of R_1.

$$R_1 = \omega^2 \left(\frac{R_2 R_3 C_4}{1 + \omega^2 C_4^2 \cdot R_4^2}\right) R_4 C_4$$

$$= \boxed{\frac{\omega^2 C_4^2 \cdot R_2 R_3 R_4}{1 + \omega^2 C_4^2 \cdot R_4^2}}$$

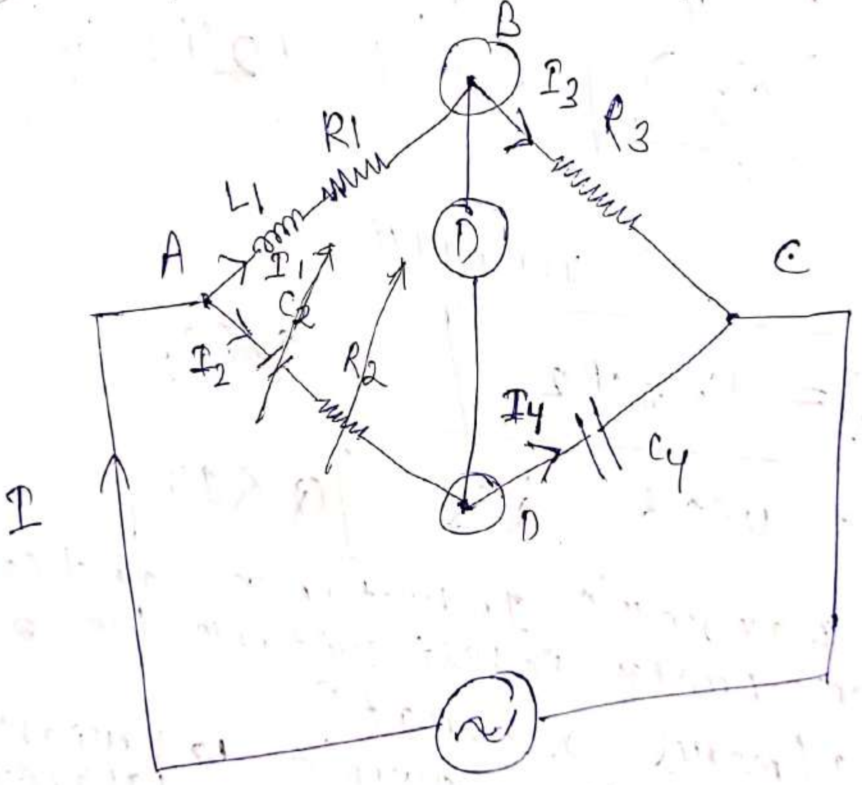
$Q = \frac{\omega . L_1}{R_1}$, $Q = \frac{1}{\omega C_4 R_4}$

$$\Rightarrow \boxed{\uparrow Q \propto \frac{1}{C_4} \downarrow}$$

It is used to measure high quality factor of a coil. (Q>10)

— x —

Owen's Bridge :-

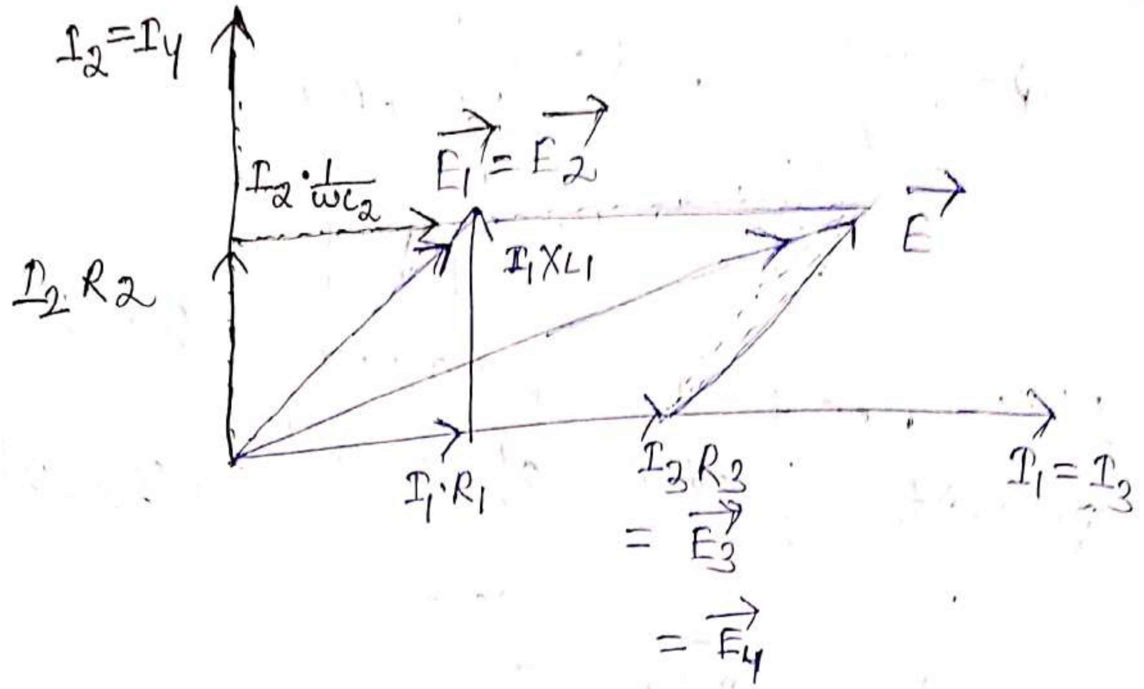


$\Rightarrow Z_1 . Z_4 = Z_2 . Z_3$

$\Rightarrow (R_1 + j\omega L_1)\left(\frac{1}{j\omega C_4}\right) = \left(R_2 + \frac{1}{j\omega C_2}\right) \times R_3$

$\Rightarrow \frac{R_1}{j\omega C_4} + \frac{\omega L_1}{\omega C_4} = R_2 R_3 + \frac{R_3}{j\omega C_2}$

$\Rightarrow -j\frac{R_1}{\omega C_4} + \frac{L_1}{C_4} = R_2 R_3 - \frac{jR_3}{\omega C_2}$



$\boxed{R_1 = \frac{R_3 C_4}{C_2}}$; $\boxed{L_1 = R_2 R_3 C_4}$

variable

$\boxed{Q = \omega \cdot C_2 \cdot R_2}$ $Q \propto C_2$

↳ It is used for $\boxed{Q < 10}$

But maxwell's Inductance and capacitance Bridge is best suitable for Q measure $Q<10$, (more accurate as compare than owen's Bridge.)

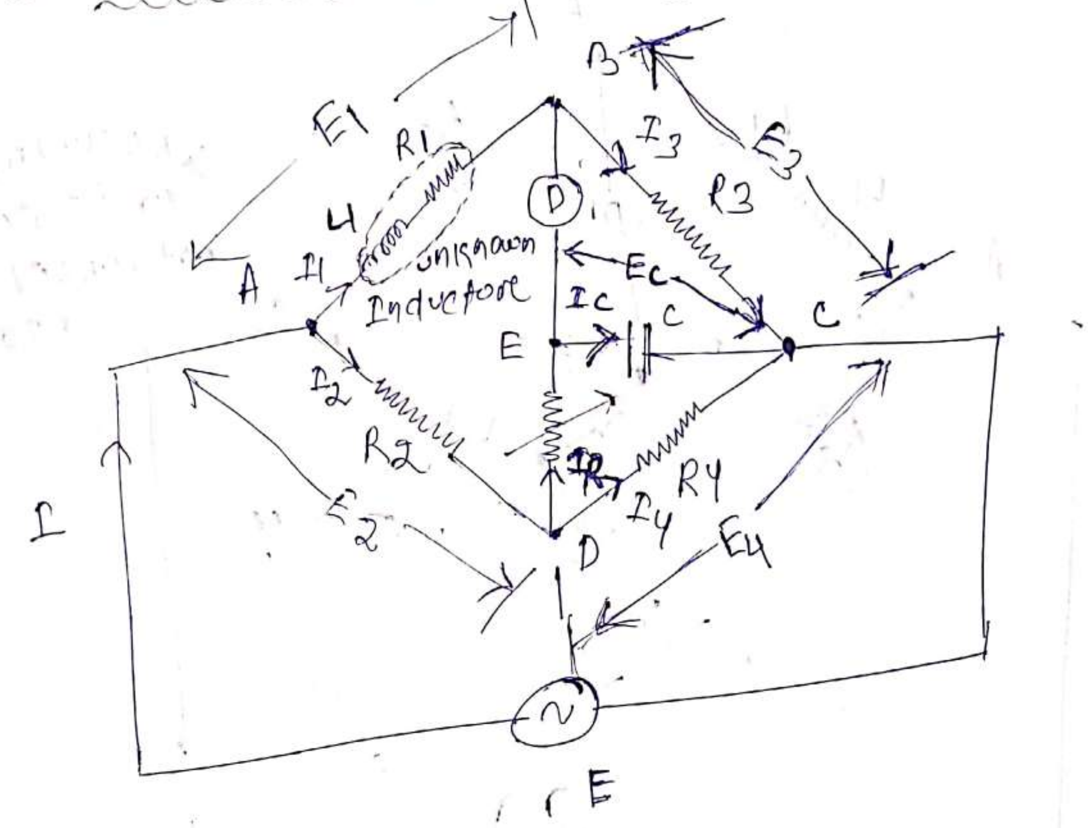
↳ owen's Bridge has 2 capacitor and more dissipation loss.

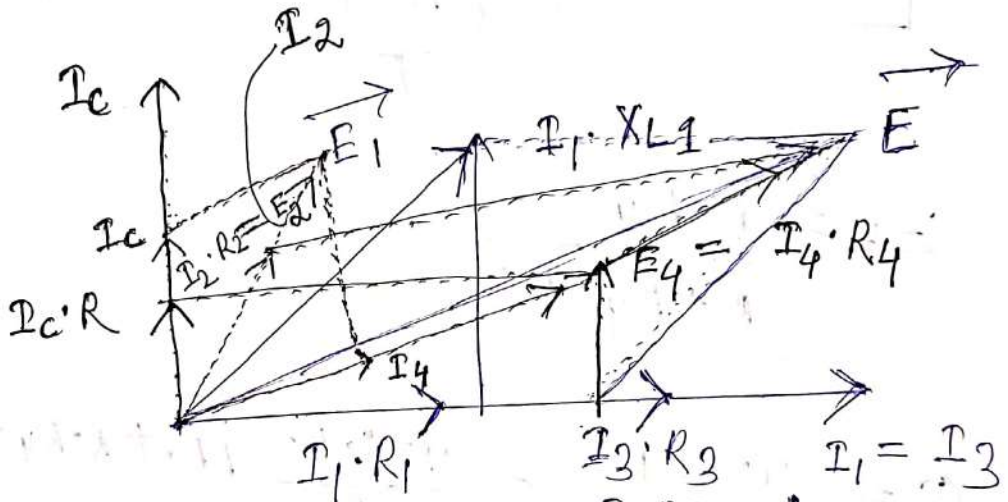
↳ Variable capacitor is difficult to made. $C = \frac{\epsilon A}{d}$ All are fixed

↳ Fixed resistor is difficult to make.

↳ both Fixed and variable inductors are difficult to make. $L = \frac{N\phi}{I}$

⑤ Anderson's Bridge :





$I_1 = I_3$

$= E_3$

$= E_c$

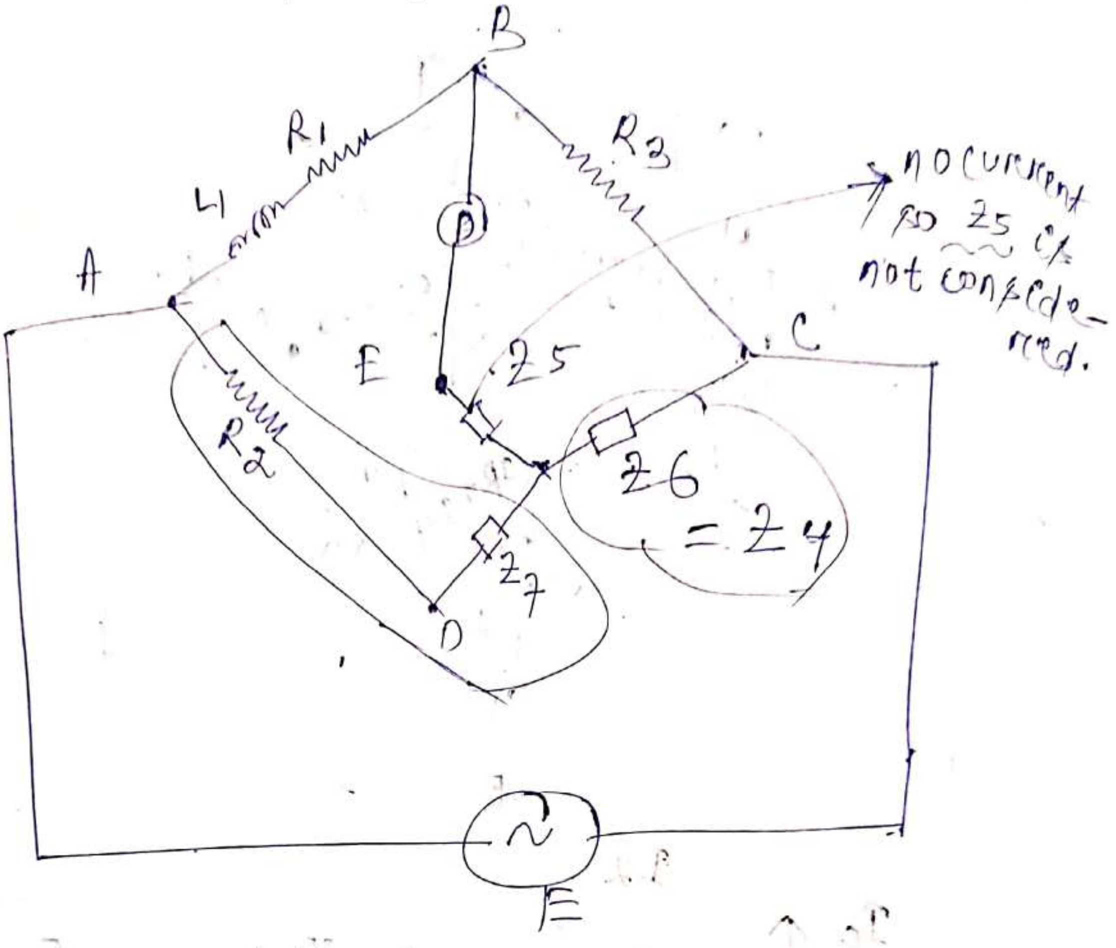
$= I_c \cdot \frac{1}{\omega C}$

$$Z_1 \cdot Z_4 = Z_2 \cdot Z_3$$

⇒

$$\Rightarrow \boxed{R_1 = \frac{R_2 \cdot R_3}{R_4}}$$

$$\boxed{L_1 = \frac{C \cdot R_3}{R_4}\left[R R_2 + R \cdot R_4 + R_2 \cdot R_4\right]}$$



$$Z_7 = \frac{R \cdot R_4}{R + R_4} + C$$

$$Q = \frac{\omega \cdot L_1}{R_1} = \frac{\frac{\omega C R_3}{R_4}\left[R R_2 + R \cdot R_4 + R_2 R_4\right]}{\frac{R_2 \cdot R_3}{R_4}}$$

$$= (X)$$

→ since here fixed capacitor is there, not variable capacitor. So ~~we~~ ~~can~~ resonance can not be obtained. Hence we can not ~~me~~ measure the value of ~~(Q)~~ Quality factor (Q) here.

It is fastest Bridge.

Hay's Bridge → ~~Low~~ slowest Bridge.

Que: A Bridge ckt. for the measurement of effective resistance and inductance of an iron core coil. The arm AB is consisting of an unknown inductor. Arm BC : a pure resister R3, arm CD : a lossless capacitor : C4, Arm DA : A series with capacitor C2 in resistance R2. under balance condn R3 = 10Ω, R2 = 842Ω, C2 = 0.135 MF, C4 = 1MF. calculate the Reff and self inductance of a coil. Derive the eqn for balancing and draw the phasor diagram under balance condn.

Soln: $R_2 = 842\ \Omega$, $R_3 = 10\ \Omega$

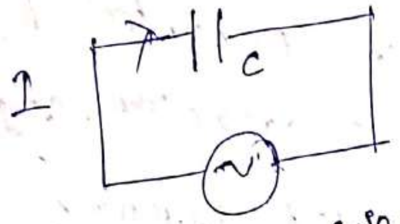
$C_2 = 0.135\ MF$, $C_4 = 1\ MF$.

It is owen's Bridge.

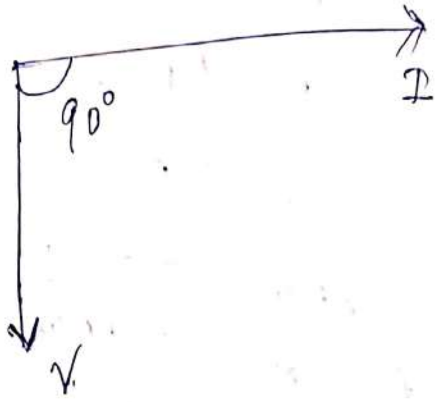
MEASUREMENT OF CAPACITANCE (AC BRIDGES) :-

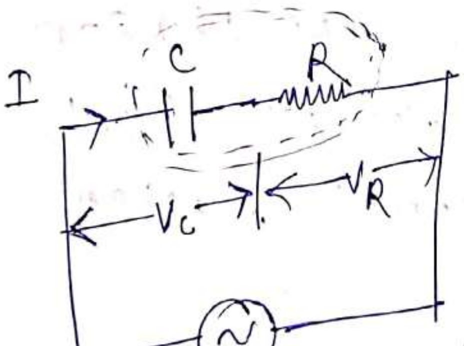
1. Desauty Bridge.
2. Modified Desauty Bridge.
3. Schering Bridge.

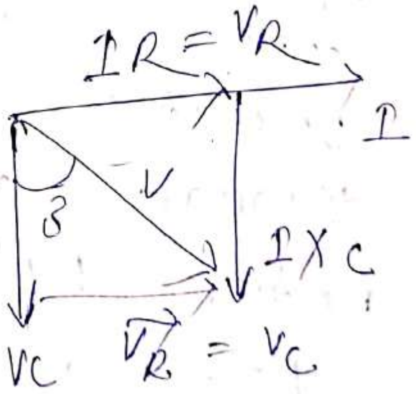
pure capacitore



$V = V_m \sin \omega t$







$V = V_m \sin \omega t$

$\vec{V} = \vec{V_R} + \vec{V_C}$

δ = Loss angle,

$\tan \delta = \frac{V_R}{V_C} = \frac{I \cdot R}{I \cdot X_C} = \frac{R}{(1/\omega c)}$

~~D.fa~~ Dissipation factor (D-factor)

$= \tan \delta = \omega C R$

Q-factor = $\frac{\omega L}{R} = \frac{1}{\omega CR}$

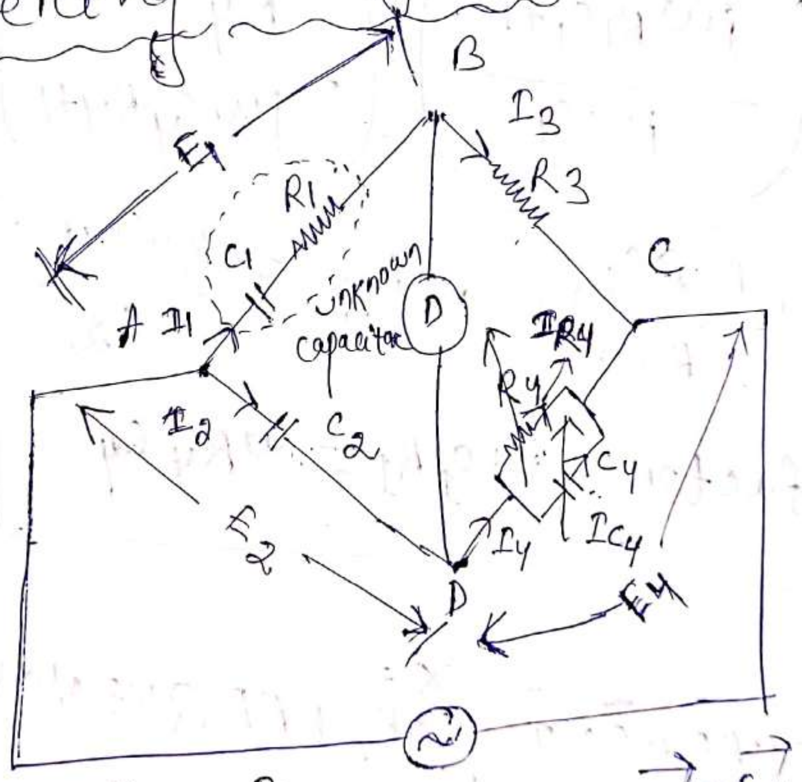
for a pure ~~res~~ capacitor

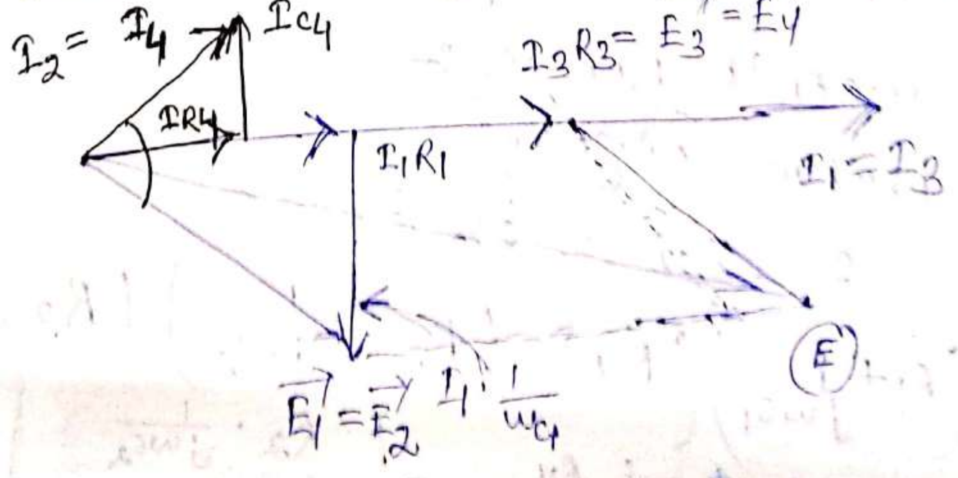
$\delta = 0$,

for a pure Resistor $\delta = 90^0$

δ = loss angle.

Schering Bridge :-





$$Z_1 Z_4 = Z_2 Z_3$$

$$\Rightarrow \left(R_1 + \frac{1}{sC_1}\right)\left(R_4 \parallel \frac{1}{sC_4}\right) = sC_2 \cdot R_3$$

$$\Rightarrow \left(\frac{sR_1C_1+1}{sC_1}\right)\left(\frac{\frac{R_4}{sC_4}}{R_4+\frac{1}{sC_4}}\right) = sC_2 : R_3$$

$$\Rightarrow \left(\frac{sR_1C_1+1}{sC_1}\right)\left(\frac{R_4}{sC_4R_4+1}\right) = sC_2 \cdot R_3$$

$$\Rightarrow \left(\frac{j\omega R_1C_1+1}{j\omega C_1}\right)\left(\frac{R_4}{j\omega C_4R_4+1}\right) = j\omega C_2R_3$$

$$C_1 = \frac{R_4 C_2}{R_3}, \quad R_1 = \frac{R_3 C_4}{C_2}$$

$$\text{D-factor} = \omega C_1 R_1 = \omega R_4 C_4$$

MEASUREMENT OF FREQUENCY :

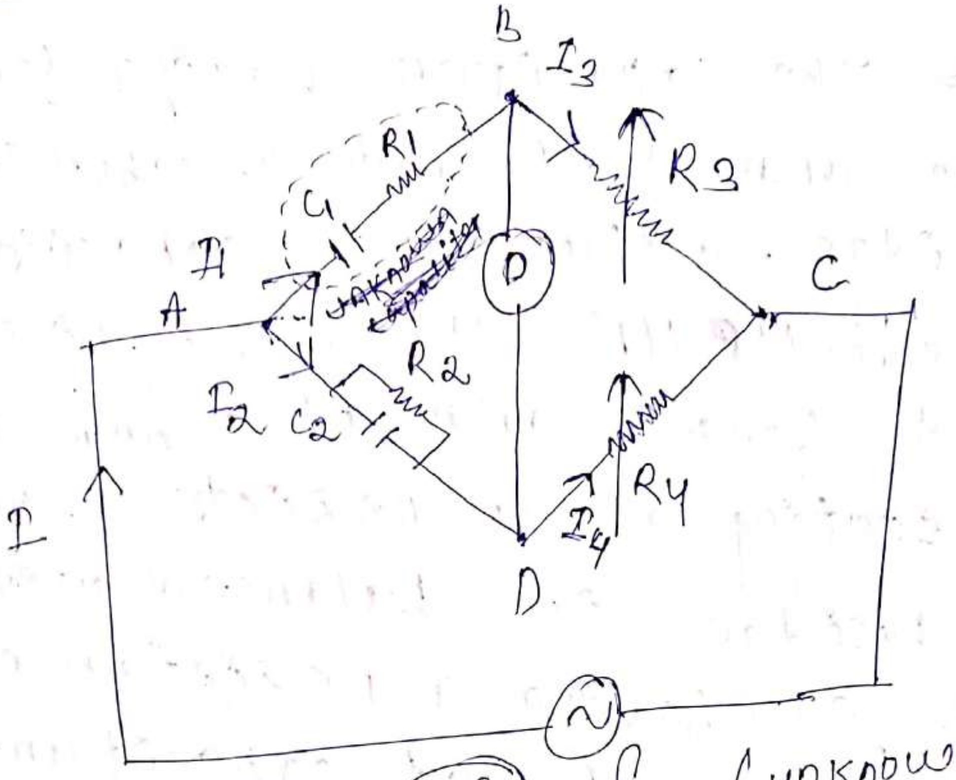
Ween's Bridge :-

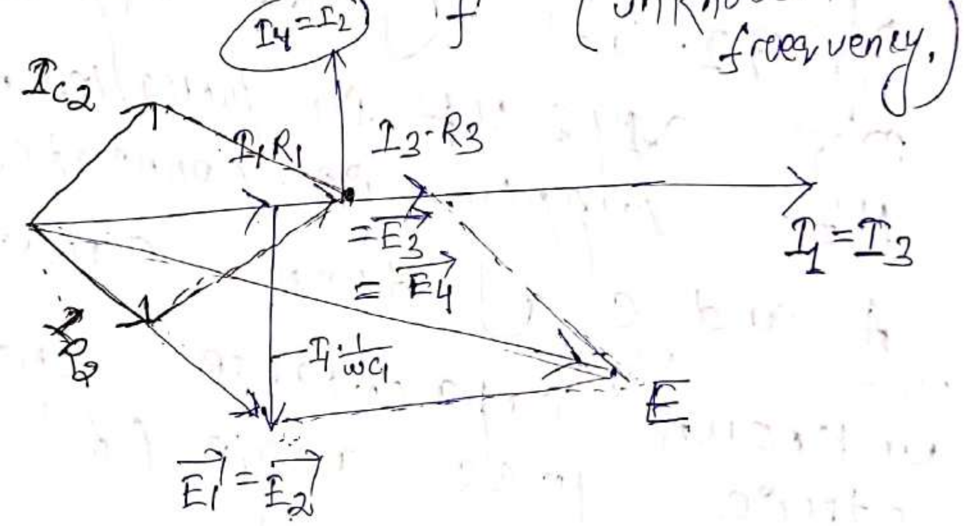
phasor Diagram :

$$Z_1 \cdot Z_4 = Z_2 \cdot Z_3$$

$$\left(R_1+\frac{1}{j\omega C_1}\right)(R_4) = \left(R_2 \parallel \frac{1}{j\omega C_2}\right)(R_3)$$

$$\Rightarrow R_1R_4 - j\frac{R_4}{\omega C_1} = \left(\frac{R_2 \cdot \frac{1}{j\omega C_2}}{R_2+\frac{1}{j\omega C_2}}\right) \cdot R_3$$





$$\Rightarrow R_1 R_4 - j \cdot \frac{R_4}{\omega C_1} = \left(\frac{R_2}{j R_2 \omega C_2 + 1} \right) \cdot R_3$$

$$\Rightarrow R_1 R_4 - j \frac{R_4}{\omega C_1} = \frac{R_2 R_3}{1 + j R_2 \omega C_2}$$

$$\omega^2 = \frac{1}{R_1 R_2 C_1 C_2} \Rightarrow \omega = \frac{1}{\sqrt{R_1 R_2 C_1 C_2}}$$

$$\Rightarrow \boxed{f = \frac{1}{2\pi \sqrt{R_1 R_2 C_1 C_2}}}$$

Q - METER

↳ Q-meter stands for "quality factor" meter. whose principle of operation is series Resonance.

↳ voltage magnification property exhibited by a series RLC ckt. is used in the at resonance design of Q-meter.

↳ There are 3 type of connection of Q-meter:

① Direct connection / Direct measurement mode:

It is used for measurement of various electrical properties of a test coil is like.

↳ True (or) actual quality factor of coil (Q-coil).

↳ self inductance of a test coil (L)

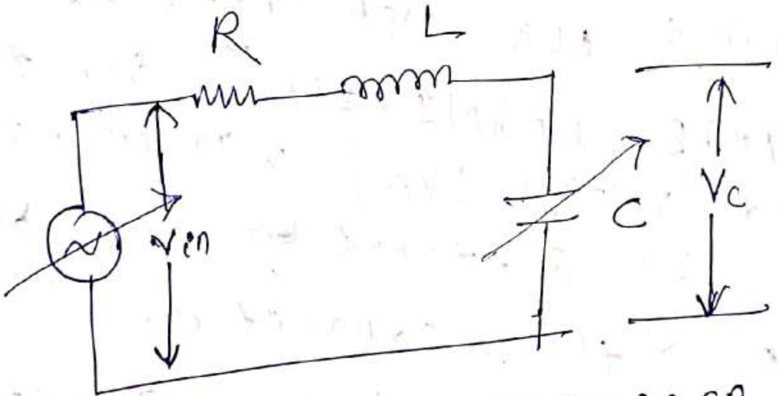
↳ self capacitance of a coil (or) distributed capacitance of coil (Cd).

→ Resistance of coil (Rcoil).

(ii) series connection (elements are connected in series), used for low impedance measurement.

(iii) shunt connection (or) parallel connection (elements are connected in parallel) used for high impedance measurement.

series RLC ckt :-



condition for Resonance $X_L = X_C$

$$\Rightarrow \omega \cdot L = \frac{1}{\omega \cdot C} \Rightarrow 2\pi f \cdot L = \frac{1}{2\pi f \cdot C}$$

Frequency at Resonance

$$2\pi f \cdot L = \frac{1}{2\pi f \cdot C} \Rightarrow \boxed{f = \frac{1}{2\pi\sqrt{LC}}}$$

→ Impedance at Resonance :-

$$Z = R + j\left(\omega L - \frac{1}{\omega C}\right)$$

at Resonance, $\omega L = 1/\omega C$

$$\boxed{\therefore Z = R}$$

→ capacitor ~~across~~ voltage at resonance is,

$$V_C = I * X_C = \frac{V_{in}}{Z} * X_C$$

$$= \left[\frac{X_C}{Z}\right] \cdot V_{in}$$

(minimum)

at resonance : $Z = R$

$$\boxed{\therefore V_{C(max)} = \left[\frac{X_C}{R}\right] V_{in}}$$

$$V_{C(max)} = \left(\frac{X_L}{R}\right) V_{in}$$

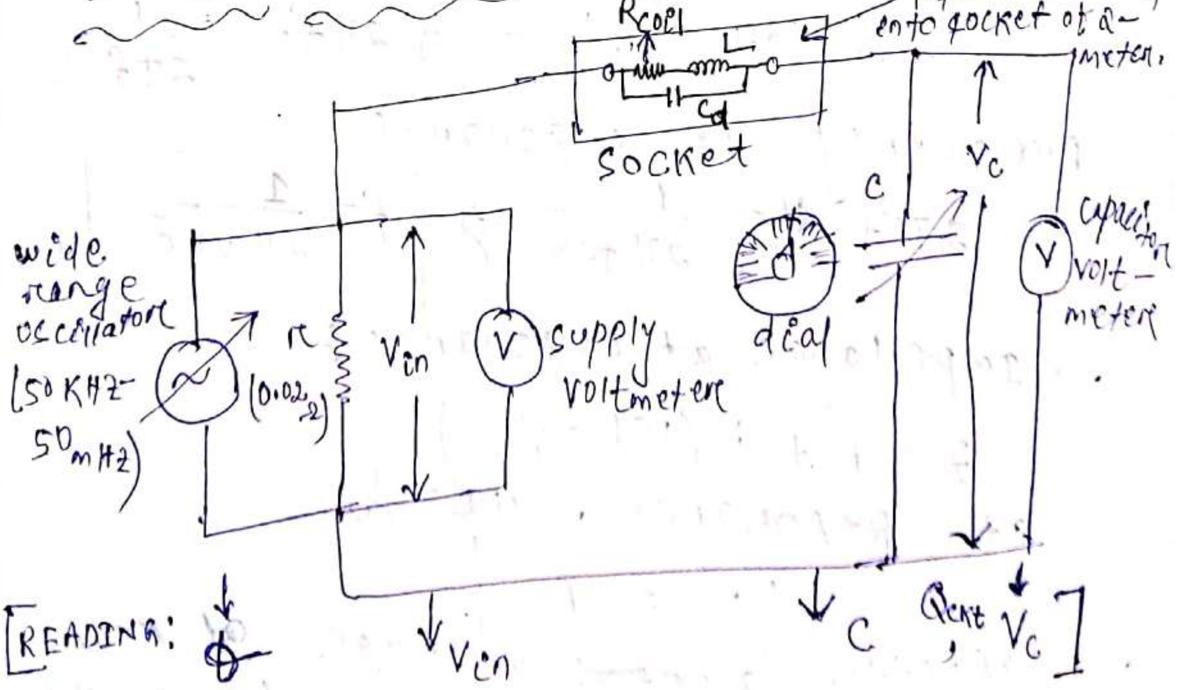
$$\Rightarrow \boxed{V_{Cmax} = Q \cdot V_{in}}$$ where

Q = quality factor

$$Q = \frac{X_L}{R} \text{ (or) } \frac{X_C}{R}$$

↳ A series RLC ckt acts as "VOLTAGE MAGNIFIER" i.e. the applied voltage (V_{in}) will be magnified by Q-times and appears across the capacitor.

Direct connection of the Q-meter:



[READING: ϕ, V_{in}, C, Q_{ckt}, V_C]

V_{in} – oscillatory o/p voltage.

rc – Insertion Resistance.

(* Rsh = shunt Resistance.
* 0.02 Ω (or) 0.05 Ω.)

f – Resonant frequency

Rcoil – Resistance of test coil.

L – self inductance of ~~test~~ coil.

C_d – self capacitance of Test coil.

C – Tuning capacitance (or) Resonating capacitance.

V_c – voltage across capacitor.

working :- Introduce the test coil on to the socket of the Q-meter.

↳ set the frequency and o/p voltage (f, V_{in}), and ~~=~~ Resonating capacitance till the capacitor ~~voltage~~ voltmeter indicates maximum voltage.

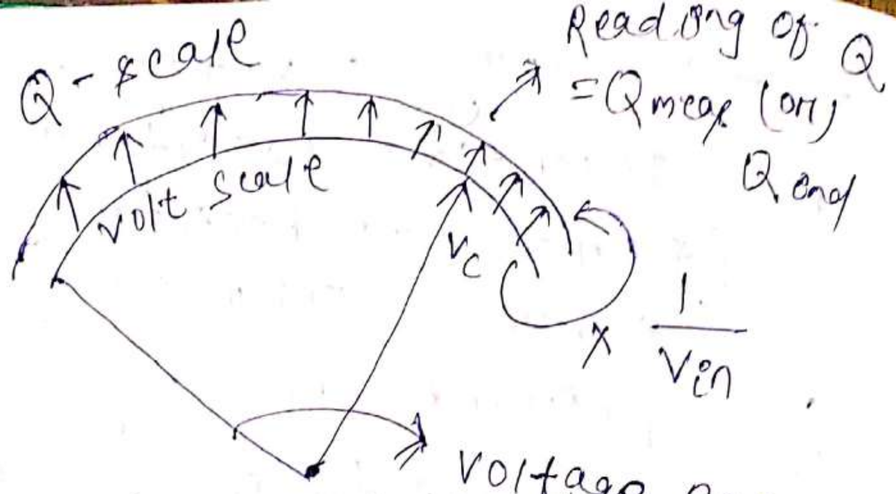
↳ Takedown, the possible readings from Q-meter.

↳ Then, Q can be calculated as:

$$Q = \frac{\text{capacitor voltmeter Reading}}{\text{supply voltmeter Reading}}$$

$$= \frac{V_{c\,max}}{V_{in}}$$

To avoid such calculations, the designer provides a scale calibrated to read Q, as given below.



Voltage Response

$$\boxed{Q = \underbrace{\left[\frac{1}{V_{in}}\right]}_{(X)} \times V_c}$$

[Q - volt scale]

↳ so the capacitor voltmeter indicates Q and also voltage. As such it is also called as Q - volt meter.

↳ The indicated Q-factor is not true Q-factor of the coil. But; it is entire ckt Q. i.e.

$$Q_{true} = \frac{\omega L}{R_{coil}} \quad (or) \quad \frac{1}{\omega C \cdot R_{coil}}$$

$$= Q_{coil}$$

But,

$$Q_{measured} = \frac{\omega L}{R_{coil} + r} \quad (or) \quad \frac{1}{\omega (C + C_d)(R_{coil} + r)}$$

$$= \boxed{Q_{ckt}}$$

The Resulting difference between the measured and true Q is error in Q - measurement.

$$\text{Error} = Q_{meas} - Q_{true}$$

$$\%\text{Error} = \frac{Q_{meas} - Q_{true}}{Q_{true}} \times 100\%$$

↳ This error in Q-measurement is due to 2 error sources.

① Insertion Resistance (r)

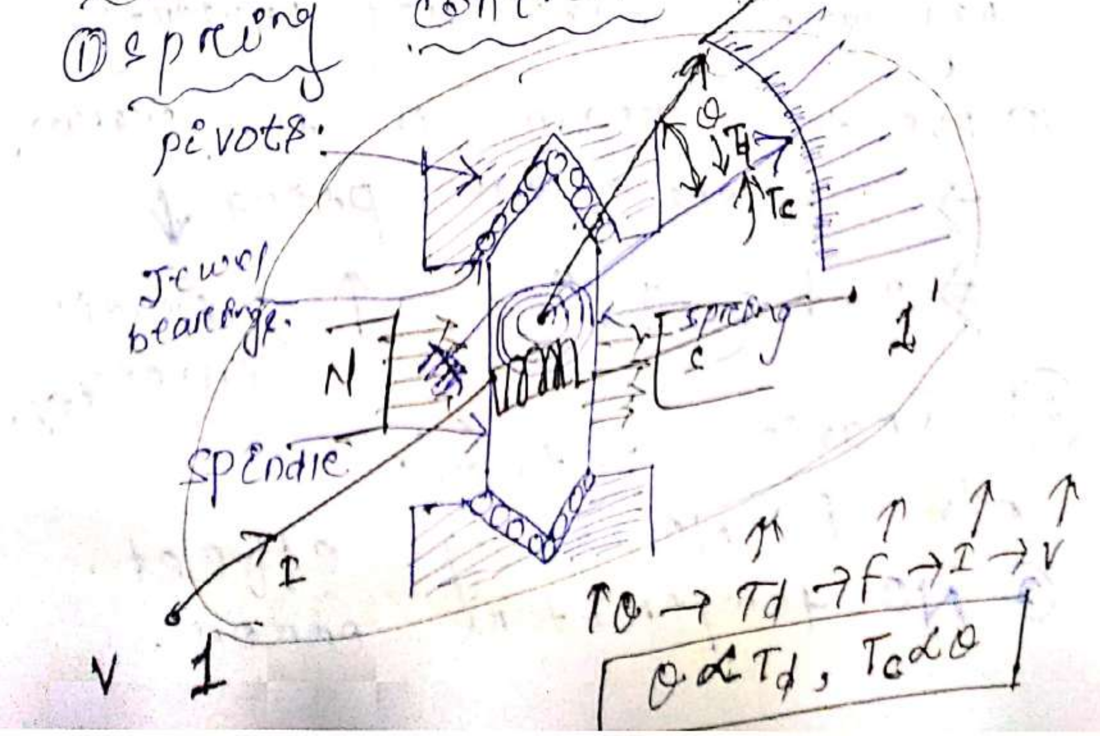
② C_d

↳ The Q-voltmeter is also known as ckt - Q meter.

ELECTRICAL MEASUREMENT :-

mechanism for producing control Force :- (T_c) :-

① spring control.



$$T\theta \rightarrow T_d \rightarrow f \rightarrow I \rightarrow V$$

$$\boxed{\theta \propto T_d,\ T_c \propto \theta}$$

ELECTRONIC MEASUREMENT:-

① Error in Q-measurement due to r :-

↳ $Q_{true} = \frac{\omega L}{R_{coil}}$

$$Q_{meas.} = \frac{\omega L}{R_{coil} + r}$$

↳ % Error due to r $= \frac{Q_{meas.} - Q_{true}}{Q_{true}} \times 100$

$$= \frac{\frac{\omega L}{R_{coil} + r} - \frac{\omega L}{R_{coil}}}{\frac{\omega L}{R_{coil}}} \times 100.$$

$$\boxed{\% \text{ Error} = \frac{-r}{R_{coil} + r} \times 100 \%}$$

→ correction factor $= \frac{Q_{true}}{Q_{meas.}}$

$$= \frac{\omega L / R_{coil}}{\omega L / R_{coil} + r} = \frac{R_{coil} + r}{R_{coil}}$$

i.e. $\boxed{Q_{true} = Q_{meas.} \left[1 + \frac{r}{R_{coil}} \right]}$

where $Q_{meas.}$ = Reading of ckt-Q meter

r = Insertion resistance

R_{coil} = coil Resistance

Note:- This error in Q-measurement due to 'r' is very low and negligible, since r << Rcoil.

Note:- error in Q-measurement due to residual inductance is negligible, since residual inductance << L.

↳ $Q_{true} = \frac{1}{\omega C R_{coil}}$

$$Q_{meas.} = \frac{1}{\omega (C+C_d)\cdot(R_{coil}+r)}$$

$$\cong \frac{1}{\omega (C+C_d)\cdot R_{coil}} \quad (\because r << R_{coil})$$

↳ % Error due to C_d $\Big\} = \frac{Q_{meas} - Q_{true}}{Q_{true}}$

$$= \frac{\frac{1}{\omega(C+C_d)R_{coil}} - \frac{1}{\omega C\cdot R_{coil}}}{\frac{1}{\omega\cdot C\cdot R_{coil}}}$$

$$\boxed{\%\text{Error} = \frac{-C_d}{C+C_d} \times 100\,\%}$$

↳ correction factor $= \frac{Q_{true}}{Q_{meas.}}$

$$= \frac{\frac{1}{\omega C\cdot R_{coil}}}{\frac{1}{\omega(C+C_d)\cdot R_{coil}}}$$

$$= \frac{C+C_d}{C}$$

$$\boxed{\therefore Q_{true} = Q_{meas}\left[1 + \frac{C_d}{C}\right]}$$

where, Q_{meas} = Reading of ckt Q-meter.

C = Reading taken from calibrated scale of dial of tuning capacitor.

C_d = To calculate the true Q of coil, the value of C_d of coil is required. since the correction factor involves C_d of the coil. so always first measure C_d.

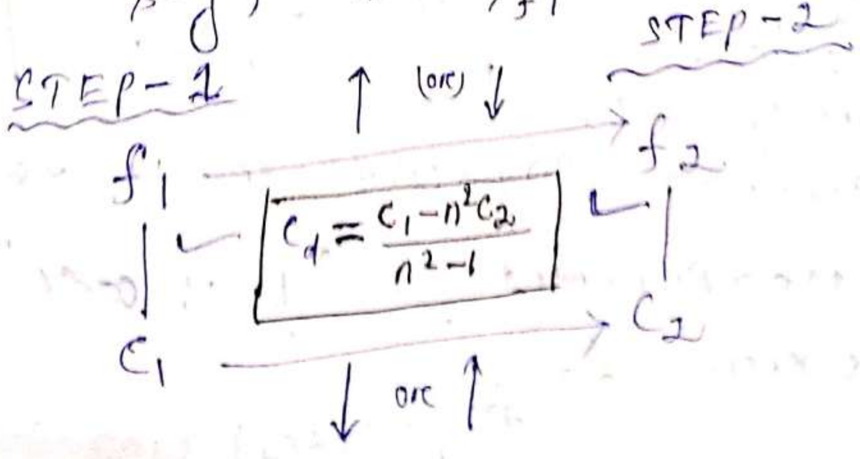
(X) measurement using "direct connection of Q-meter".

① measurement of "C_d" of coil :-

Introduce the given test coil in to socket of Q-meter and resonate twice at f_1 and f_2.

↳ Resonate 2 times :- f_1 and f_2.

say, $n = f_2/f_1$.



$$\boxed{C_d = \frac{C_1 - n^2 C_2}{n^2 - 1}}$$

↳ Note down Readings from Q-meter.

step-1 readings	step-2 readings
f_1, v_{in}, c_1, Q_1, v_{c_1}.	f_2, v_{in}, c_2, Q_2, v_{c_2}.
$f_1 = \frac{1}{2\pi\sqrt{L(c_1+c_d)}}$ —①	$f_2 = \frac{1}{2\pi\sqrt{L(c_2+c_d)}}$ —②
$Q_1 = \frac{V_{c1}}{V_{in}}$	$Q_2 = \frac{V_{c2}}{V_{in}}$

$\frac{\text{eqn}-①}{\text{eqn}-②}$ $\frac{f_1}{f_2} = \frac{\frac{1}{2\pi\sqrt{L(c_1+c_d)}}}{\frac{1}{2\pi\sqrt{L(c_2+c_d)}}}$

$\Rightarrow \cancel{\frac{f_1}{n \cdot f_1}} = \sqrt{\frac{\cancel{L}(c_2+c_d)}{\cancel{L}(c_1+c_d)}}$

Squaring on both sides we get

$\Rightarrow \frac{1}{n^2} = \frac{c_2+c_d}{c_1+c_d}$ $\Rightarrow n^2 c_2 + n^2 \cdot c_d = c_1 + c_d$

$\Rightarrow n^2 c_d - c_d = c_1 - n^2 c_2$

$\Rightarrow c_d(n^2-1) = c_1 - n^2 \cdot c_2$

$\Rightarrow \boxed{c_d = \frac{c_1 - n^2 \cdot c_2}{n^2 - 1}}$

where
$n = f_2 : f_1$
c_1 and c_2 are
Resonating capacitance values.

② Measurement of "L of coil":

we know $f = \frac{1}{2\pi\sqrt{L(c+c_d)}}$

squaring on both sides,

$$f^2 = \frac{1}{(2\pi)^2 . L . (c + c_d)}$$

$$\Rightarrow \boxed{L = \frac{1}{(2\pi f)^2 [c + c_d]}}$$

∴ first measure c_d and then L can be measured using either f_1, c_1, c_d (or) f_2, c_2, c_d.

i.e. $$L = \frac{1}{(2\pi f_1)^2 . [c_1 + c_d]}$$

(or)

$$L = \frac{1}{(2\pi f_2)^2 . [c_2 + c_d]}$$

Ques: data : f_1, c_1, f_2, c_2

(i) c_d = ? , (ii) L = ?

③ Measurement of "Q_{true} of coil" :-

we know: $\boxed{Q_{true} = Q_{meas}.[1 + \frac{c_d}{c}]}$

∴ first measure "c_d of coil" Then, measure Q_{true} of coil using either Q_1, c_1, c_d (or) Q_2, c_2, c_d.

i.e. $Q_{true} = Q_1 [1 + \frac{c_d}{c_1}]$

(or)

$$Q_{true} = Q_2 [1 + \frac{c_d}{c_2}]$$

④ Measure-ment of Resistance of coil Rcoil :-

we know, $Q_{true} = \frac{\omega L}{R_{coil}}$

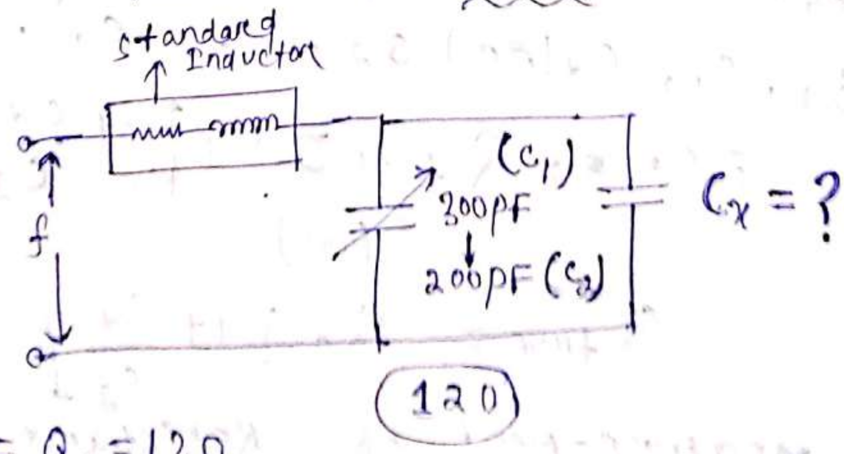
i.e. $\boxed{R_{coil} = \frac{\omega L}{Q_{\cancel{coil}\,true}}}$

∴ first measure "C_d of coil" and then measure L and Q_{true}, Then only ~~Qtrue~~ R_{coil} can be measured.

— x —

Ques A Reading of 120 is obtained when a standard inductor is connected on the ckt of Q-meter and the variable capacitor is adjusted to 300pF. A loss less capacitor C_x is then connected in ~~paramet~~ parallel with and same variable capacitor when the reading is obtained variable capacitor is readjusted to a value of 200pF. Then the value of C_x is —.

Solⁿ



$Q_1 = Q_2 = 120$

$$\Rightarrow \frac{1}{\omega_0 \cdot C_1 \cdot R_{coil}} = \frac{1}{\omega \cdot (C_2 + C_X) R_{coil}}$$

$$\Rightarrow C_1 = C_2 + C_X$$

$$\Rightarrow \boxed{C_X = C_1 - C_2} \rightarrow$$ unknown capacitance measurement using Q-meter.

$$= 300pf - 200pf$$

$$= 100pF$$

Ques: A coil is tested with a Q-meter and the self capacitance of the coil is found to be 820pF. Resonance has occured at a frequency of $10^6 \frac{rad}{second}$, with a capacitance of 9.18nF. What is the inductance of the coil?

Sol^n: $\omega = 10^6 \frac{rad}{sec}$, $C_d = 820\,pF$

$c = 9.18\,nf$

$$L = \frac{1}{(2\pi f)^2 (c + C_d)} = \frac{1}{\omega^2 \cdot (c + C_d)}$$

$$= \frac{1}{(10^6)^2 \cdot [9.18nf + 820pF)}$$

$$= \boxed{100\,\mu H}$$

Ques: A Q-meter is supplied with an oscillator having 500 mV o/p voltage. While testing an unknown coil the reading of Q-voltmeter is 20 volt. Then the Q-factor of the coil is ——.

Solⁿ:- $V_{in} = 500\,mV$, $V_{c\,max} = 10V$

$$\therefore Q = \frac{V_{c\,max}}{V_{in}} = \frac{10\ volt}{500\,mV}$$

$$= \boxed{20}$$

—— x ——

Ques:- The true value of Q of coil is 245 and measured value is 244.5 Then the ratio of tuning capacitance in ckt to distributed capacitance of coil is ——.

Solⁿ:- $Q_{True} = 245$

$Q_{meas} = 244.5$

$C/C_d = ?$

C_d = capacitance of test coil.

C = Tuning capacitance.

$$Q_{True} = Q_{measured}\left[1 + \frac{C_d}{C}\right]$$

$$\Rightarrow 1 + \frac{C_d}{C} = \frac{Q_{True}}{Q_{measured}}$$

$$\Rightarrow \frac{C_d}{C} = \frac{Q_{True} - Q_{meas.}}{Q_{true}}$$

$$\Rightarrow C/C_d = \frac{Q_{True}}{Q_{True} - Q_{meas.}}$$

$$= 489$$

—— x ——

Ques:- A coil a Resistance of 10Ω is connected in direct measurement mode of Q-meter. Resonance occur with oscillator frequency is 1 MHz and resonating capacitance is set at 65 pF. Then calculate the magnitude of % Error ~~err~~ introduced in measurement of Q by insertion resistance of 0.02 Ω.

Soln:- $f = 1$ MHz, $C = 65$ pF

$R_{coil} = 10\,\Omega$, $r = 0.02\,\Omega$

% Error due to r

$$= \frac{-r}{R_{coil} + r} \times 100\,\%$$

$$= -\frac{0.02\,\Omega}{10\,\Omega + 0.02} \times 100\,\%$$

$$= -0.19\,\% \cong -0.2\,\%$$

$$|\%\,\text{Error}| = (0.2)\,\%$$

Note:- If $r = 0.05\,\Omega$ and $R_{coil} = 10\,\Omega$

$$\%\,\text{Error} = \frac{-0.05\,\Omega}{10\,\Omega + 0.05\,\Omega} \times 100\,\%$$

$$= -0.49\,\% \cong -0.5\,\%$$

Que:- A coil is tuned to resonance at 500 KHz with a resonating capacitance of 36 pF. the resonance is at 250 KHz obtained with a resonating capacitance of 106 pF. what is the self capacitance of the coil?

Soln:- $f_1 = 500\,KHZ \xrightarrow{\downarrow} f_2 = 250\,KHZ$

$C_1 = 36\,pF \xrightarrow{\uparrow} C_2 = 160\,pF$

$\rightarrow n = \frac{250\,KHZ}{500\,KHZ}$, $n = \frac{f_2}{f_1}$

$= 1/2$

$\rightarrow C_d = \frac{36pF - (0.5)^2 \cdot 160pF}{(0.5)^2 - 1}$, $C_d = \frac{C_1 - n^2 \cdot C_2}{n^2 - 1}$

$= 5.33\,pF$

—x—

Ques:- A coil is tuned to resonance at 500 KHZ with a resonating capacitance of 360 pF. When the freq. is raised to 1 MHZ, the resonance is obtained at 72 pF. ~~of~~ Then calculate what is the distributed capacitance of the coil and also find the self inductance of the coil.

Soln:- $f_1 = 500\,KHZ$; $C_1 = 360\,pF$

$f_2 = 1\,MHZ$; $C_2 = 72\,pF$

$\rightarrow n = \frac{1\,MHZ}{500\,KHZ} \Rightarrow n = 2 = f_2/f_1$

$\Rightarrow C_d = \frac{360\,pF - (2)^2 \cdot 72\,pF}{(2)^2 - 1}$, $C_d = \frac{C_1 - n^2 \cdot C_2}{n^2 - 1}$

$= 24\,pF$

$\Rightarrow L = \frac{1}{(2\pi f_1)^2 [C_1 + C_d]}$

$$= \frac{1}{(2\pi \times 500\ KHz)^2 \cdot [360pF + 24pF]}$$

$$\Rightarrow \boxed{L = 0.264\ mH}$$

—x—

Ques- A coil is tested with a Q-meter and self capacitance of the coil is found to be 24pF. Resonance has occured at 500 KHz with a capacitance of 360pF. Then the self inductance of the coil is ——.

Soln:- $\boxed{L = 0.264\ mH}$

—x—

Ques- $C = C_1$ for fundamental frequency and $C = C_2$ for 2nd harmonic. Then $C_d = ?$

Soln! $C_d = \frac{C_1 - 4C_2}{3}$

2nd harmonic = 1st overTone

—x—

Ques- Explain the working of a Q-meter. To find the self capacitance of a coil by the Q-meter the resonance is obtained ① Tuning capacitor of 1530 PF at 1MHz.

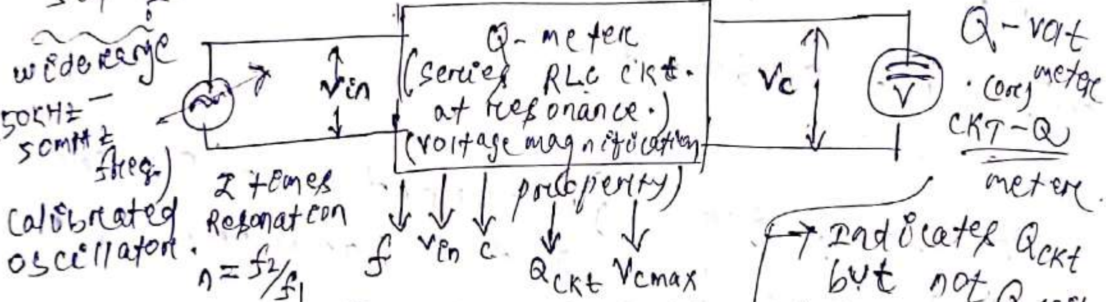
② Tuning capacitor of 162 pF at 3 MHz.

Queⁿ:- An unknown inductance Resonates at a freq. of 1 MHz with an external capacitance of 210 pF and have a Q = 100. If the freq. of the source is doubled it is found that the tuning capacitor require for resonance is 45 PF. Determine the values of the unknown inductance and other components associated with ckt ~~an~~ in the ckt.

Ans:- 10 pF.

principle of operⁿ:- series Resonance

Solⁿ:-



→ Indicates Q_{ckt} but not Q_{coil} bcz of 2 error sources: r and C_d.

$$f = \frac{1}{2\pi\sqrt{L(C+C_d)}}$$

and $Q = V_{cmax}/V_{in}$

$$C_d = \frac{C_1 - n^2 C_2}{n^2 - 1}, \quad L = \frac{1}{\omega^2(C+C_d)}.$$

$$Q_{true} = Q_{meas.}(1 + C_d/C)$$

$$R_{coil} = \frac{\omega L}{Q_{true}}$$

$C_x = C_1 - C_2$

→ # r

→ $Q_{true} = Q_{meas}\left(1 + \frac{r}{R_{coil}}\right)$

→ $\%\text{ Error} = \frac{-r}{R_{coil} + r} \times 100$

(negligible ∵ $r \ll R_{coil}$)

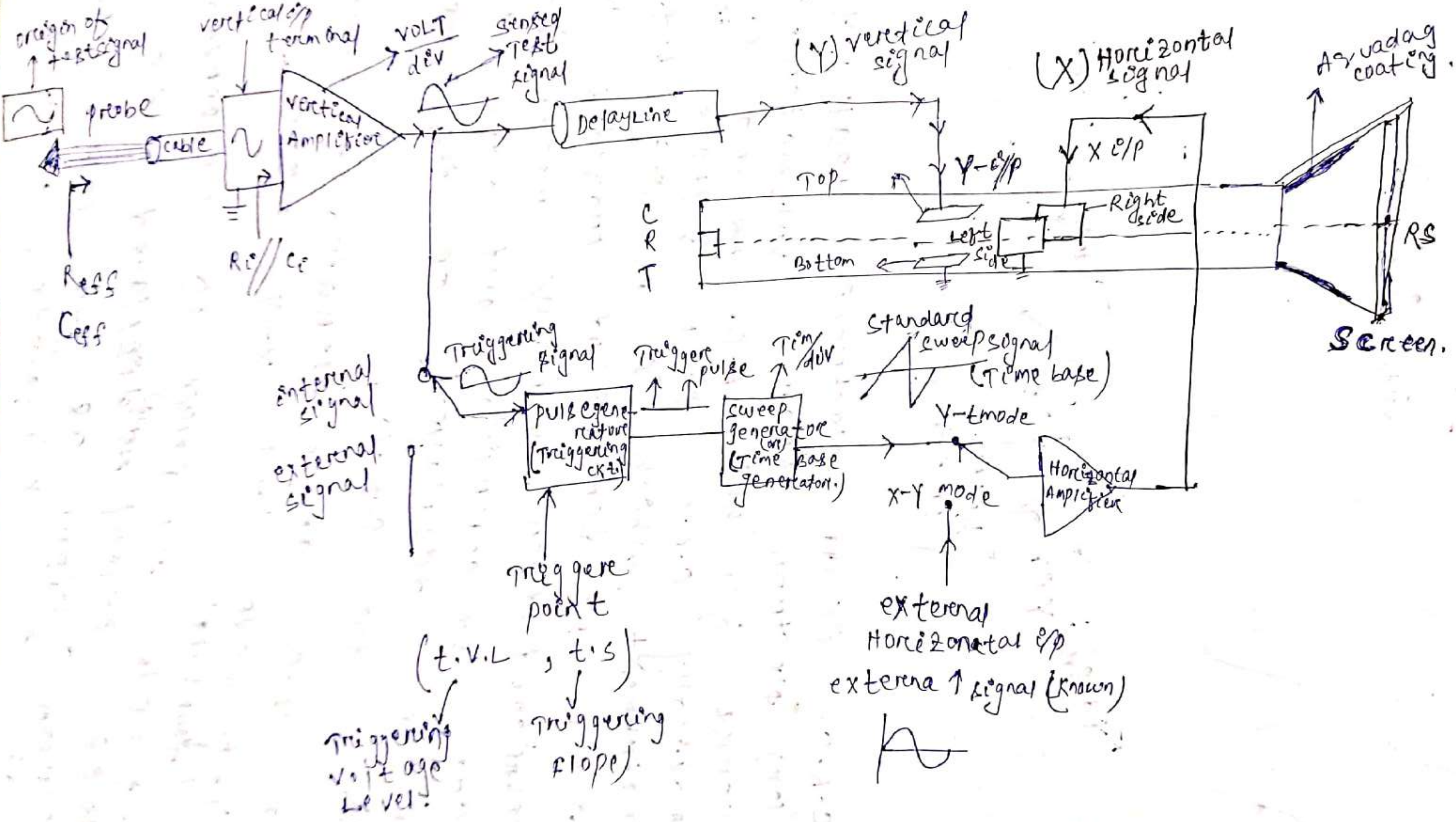
→ # C_d

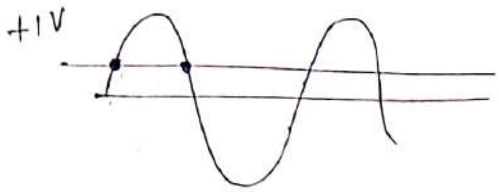
→ $Q_{true} = Q_{meas.}\left(1 + \frac{C_d}{C}\right)$

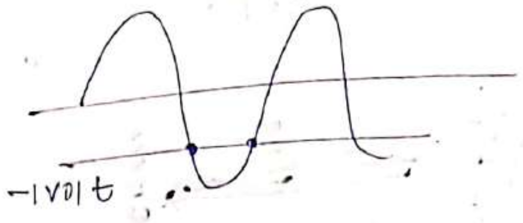
→ $\%\text{ Error} = \frac{-C_d}{C + C_d} \times 100$

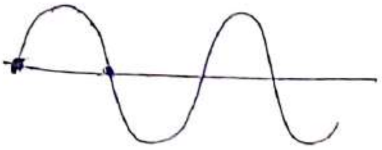
—x—

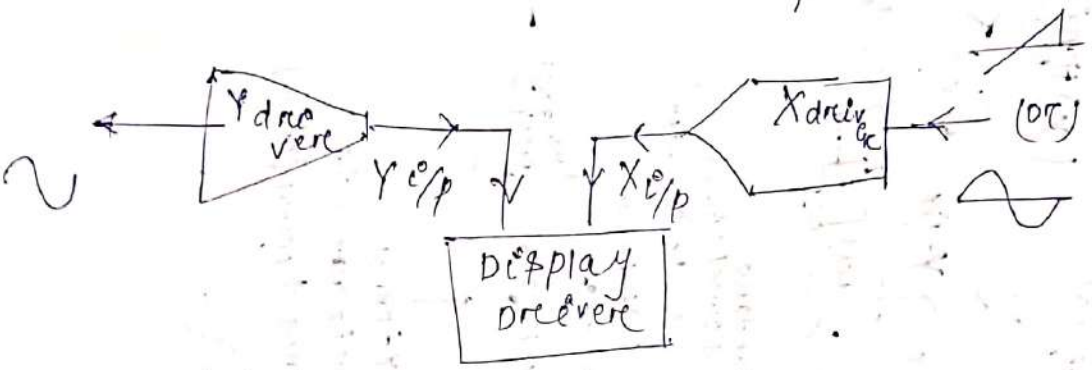
C.R.O.


origin of test signal
probe
cable
Reff
Ceff
vertical i/p terminal
Ri // Ci
Vertical Amplifier
VOLT/div
sensing Test signal
DelayLine
(Y) vertical signal
Y-i/p
Top
Bottom
Left side
Right side
C R T
(X) Horizontal signal
X i/p
Asvadag coating.
RS
Screen.
external signal
external signal
Triggering signal
Pulse generator (Triggering ckt)
Trigger pulse
Tim/div
Sweep generator (or) (Time base generator.)
Standard sweep signal (Time base)
Y-t mode
X-Y mode
Horizontal Amplifier
Trigger point
(t.V.L , t.s)
Triggering voltage Level
Triggering slope)
external Horizontal i/p
externa signal (known)









→ C.R.O. is an electronic peak volt meter (or) electron beam voltmeters that works for both A.C. ~~or~~ and D.C. inputs. Basically C.R.O. is a voltage sensitive instrument, which is nothing but an image plotter. That provides graphical representation .. various measurements can be carried out using the image displayed on the screen of the C.R.O.

↳ A C.R.O. can be operated in either Y-t mode (time base) (or) X-Y mode .. In Y-t mode, the image of the sensed signal [illegible] displayed on the left screen know as y-t plot. where as in X-Y mode, lissajous figure are displayed on the screen (known as X-Y plot.)

working :-

The Basic building blocks of C.R.O. are vertical driver, Horizontal driver, C.R.T (or) electron beam driver and power supply.

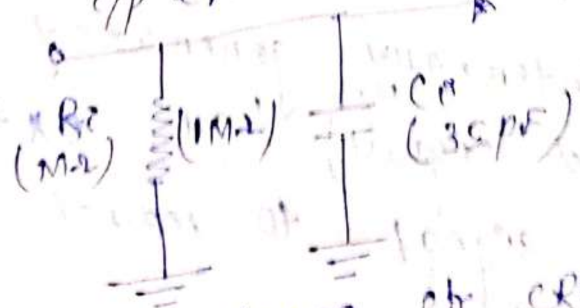
① vertical driver :-

↳ It provides a path for test signal to reach Y-i/p of C.R.T.

↳ The test signal is sensed using the probe of the oscilloscope and transmitted to vertical i/p terminals via a cable.

↳ The vertical amplifier at the front end of the vertical driver receives this sensed signal as such as most of the i/p features of C.R.O. like i/p resistance, gain, band width, rise time are decided by vertical amplifier.

i/p equivalent ckt. of CRO



∴ The i/p impedance of CRO is in the order of MΩ.

* Gain × Bandwidth = constant } for any
Risetime × Bandwidth = 0·35 } amplifier

↳ By adjusting "$\frac{\text{volt}}{\text{div}}$" the user can adjust the image of the signal on the screen i.e. the sensed test signal can either be attenuated (or) amplified.

$\frac{\text{volt}}{\text{div}}$ → Y-sensitivity control
(or)
Y-scale Adj.
(or)
Y-Amplifier setting.

~~can the~~ Gain can be controlled with this factor.

↳ A delay line is purposefully inserted between o/p of Y-amplifier and Y-i/p of C.R.T, To delay the sensed signal such that it reaches simultaneously (or) next to either sweep signal.

Horizontal Driver :- It provides a path for either internally generated sweep signal (standard signal) (or) externally applied any signal to reach X-i/p of ~~C.R~~ C.R.T.

↳ In internal triggering the o/p of vertical amplifier is used as triggering signal. (A stimulus to generate sweep.)

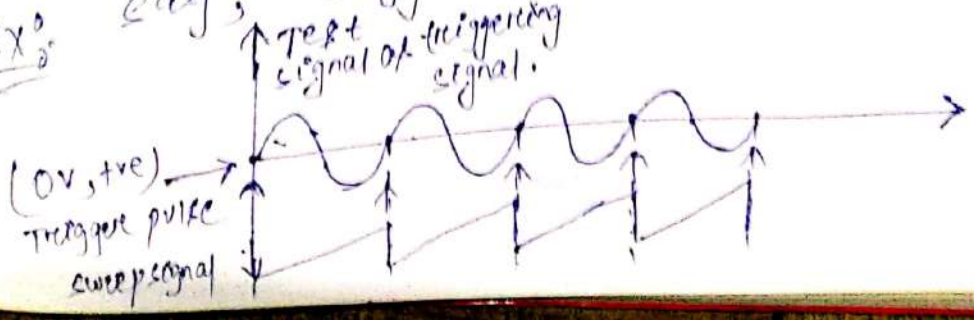
↳ The user has to select a trigger point that comprises of 2 parameters namely trigger voltage level and trigger slope.

↳ Trigger voltage level (DC only) can be selected as either 0 volt, (or) +ve, (or) -ve whereas trigger slope can be selected as either +ve (rising side of triggering signal) (or) -ve (falling side of triggering signal.)

↳ The pulse generator compares the triggering signal with preselected trigger point (T.V.L, T.S) and generates a trigger pulse whenever triggering signal coincides with trigger point.

→ Upon receiving a trigger pulse the sweep generator generates 1 cycle of sweep.

Ex: say, trigger point is 0volt, +ve.



↳ The sweep frequency can be adjusted by the user by adjusting "$\frac{\text{time}}{\text{dive}}$",

$\frac{\text{TIME}}{\text{DIV}}$ → X - scale Adjusting.

Time (or) Base setting

(or)

sweep setting

(or)

Line setting

↳ In Y-t mode, the internally generated sweep is ~~given~~ driven to X - i/p where as in X-Y mode any signal externally applied is driven to X - i/p.

⇒ C.R.T :-

— X —

ELECTRONIC ~~VOLTMETER~~ MEASUREMENT :-

C.R.T :-

↳ ~~CT~~ CRT is the heart of C.R.O. It consists beam generator at one end and beam target at other end. Beam Target is a fluoroscent screen coated inside with posphorous material. when the beam strikes the screen, visible light is produced due to phosphor excitation. The brightness of the image depends upon type of 3 factor

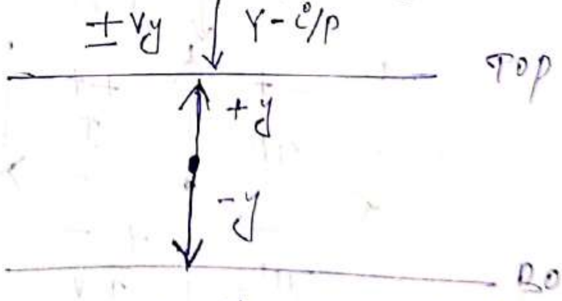
① Type of phosphore coating ② speed of electreon beam. ③ Intensity of the electron beam:-

↳ It is an evacuated glass tube consisting ~~vaccum~~ varecious element to achieve the following function namely beam generation, beam acceleration, beam focusing, beam deflection and beam target.

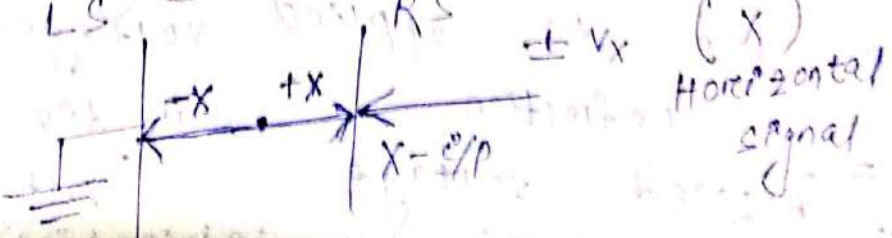
Deflection plate Assembly :-

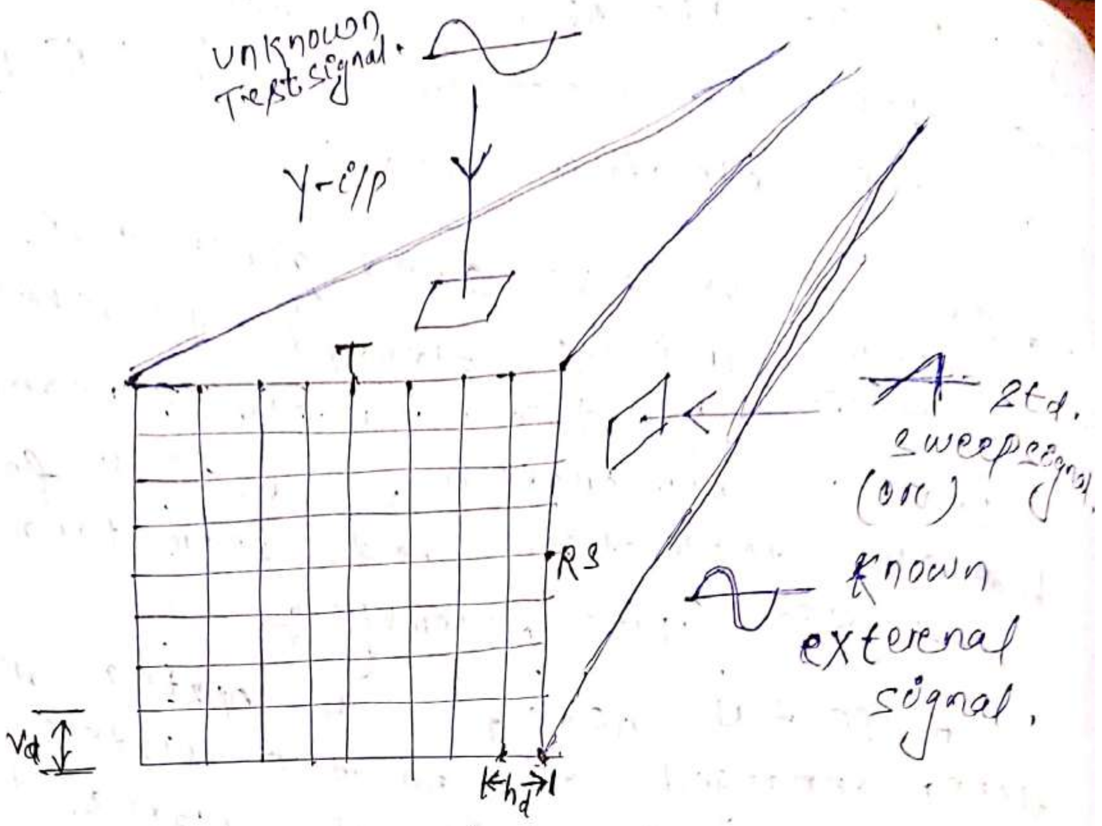
A Total no. of 4 plates are available there, arranged as two plates namely vertical deflecting pair of plates (V.D.P) and horizontal deflecting pair of plates (H.D.P).

↳ V.D.P.s are horizontally mountained plates. (i.e. Top and bottom position) that deflected electreon beam vertically (up and down deflection) (Y- vertical i/p).



↳ H.D.P.s are vertically mountained plate which deflect the electreon beam horizontally. (i.e left, right)

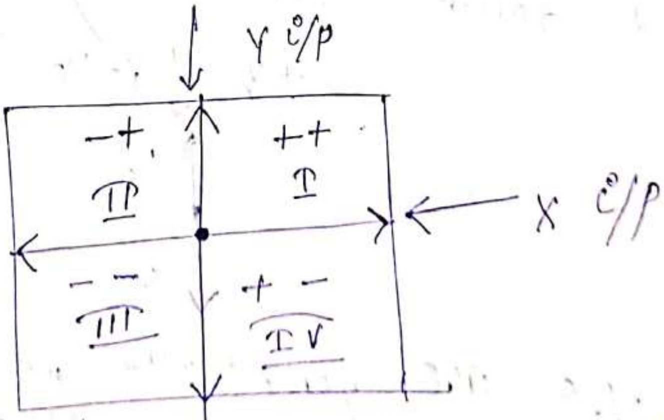




8cm X 8cm screen
(or)
8 div X 8 div screen

No. of Horizontal deflections.

No. of vertical deflections.



Deflection sensitivity :- It defines amount of distance travelled by electron beam due to applied voltage.

$$S = \frac{\text{Deflection}}{\text{Applied voltage}} \quad \text{in } \frac{\text{div}}{\text{volt}} \text{ (or) } \frac{\text{cm}}{\text{volt}}$$

i.e. "The amount of deflection per

unit deflection voltage" is deflection sensitivity.

S_V = vertical deflection sensitivity

$$= \frac{y}{V_Y}$$

S_H = Horizontal deflection sensitivity.

$$= \frac{x}{V_X}$$

Deflection factor :-

reciprocal of sensitivity is deflection factor.

$$\boxed{D_F = \frac{1}{S}} \quad \text{in} \quad \frac{1}{\left(\frac{div}{volt}\right)}$$

i.e. $\frac{volt}{div}$

Ex :- ~~0.5 div~~ $0.5 \frac{volt}{div}$ ⇒ 0.5 volts required for deflecting e^- beam by 1 div.

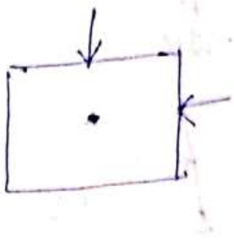
$$\frac{1}{0.5 \frac{volt}{div}} \Rightarrow 2 \frac{div}{volt}$$

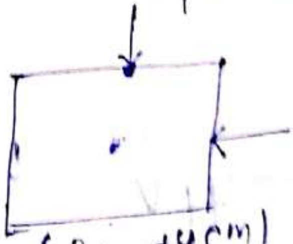
⇒ e^- beam will be deflected by 2 divisions per 1 unit deflecting voltage.

(x) DC voltages to Y and X i/ps :-

$V_Y = +2V$ dc, $S = 2 \frac{div}{volt}$

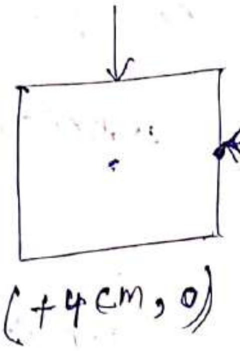
↳





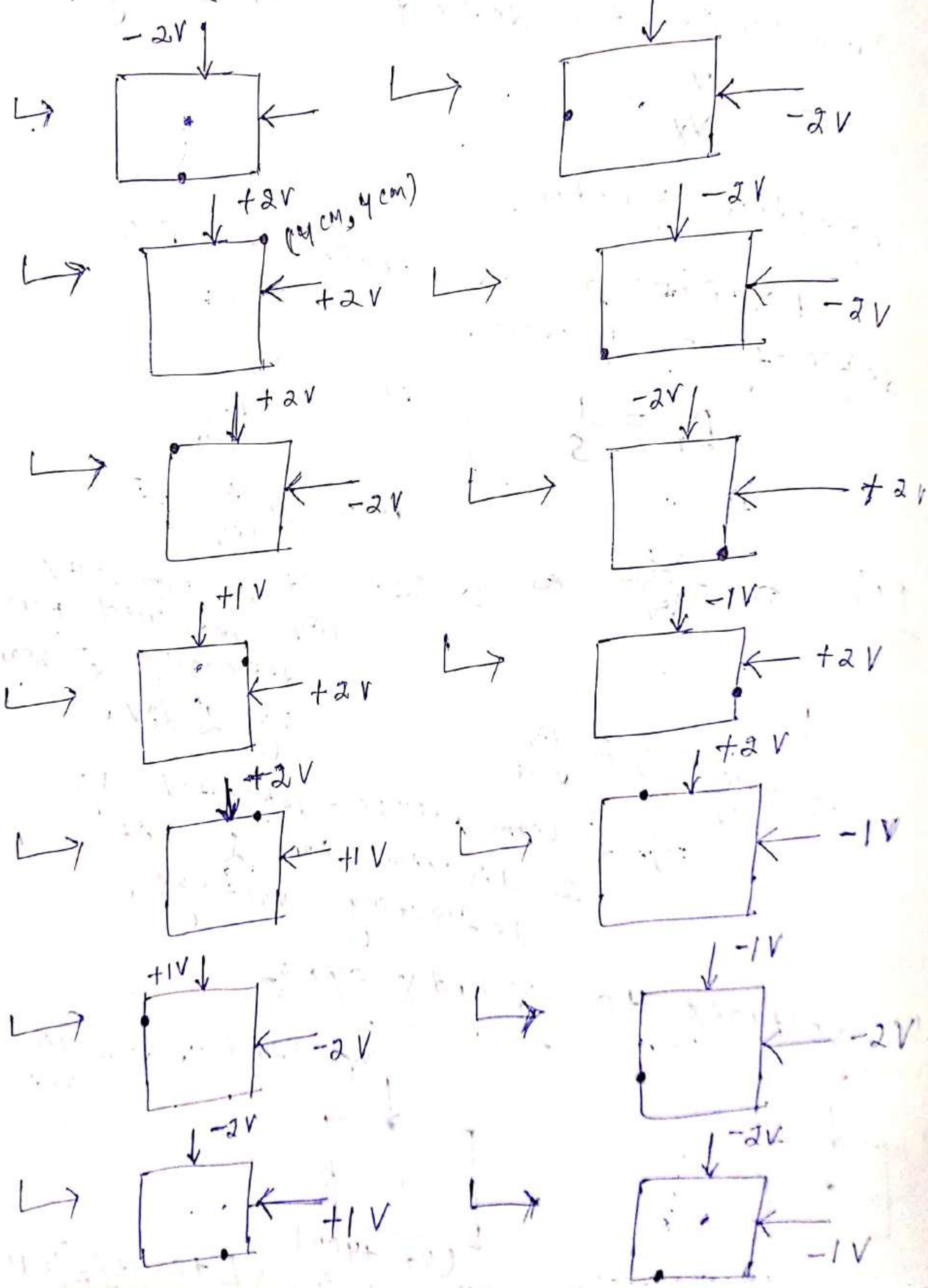
(0, +4cm)

$$y = S \times V_Y = 2 \frac{div}{1 volt} \times [+2 volt] = \boxed{4 div}$$



V_x = +2V dc
× 2 div/volt

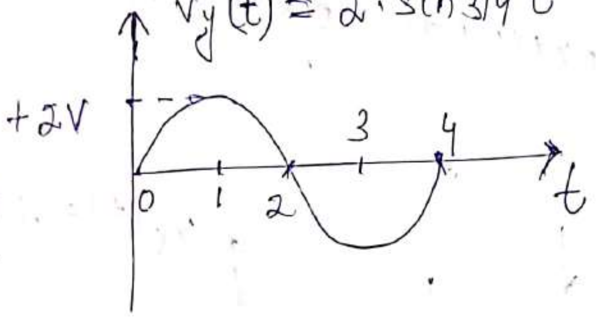
x = +4 div



(x) sensed Test signal to Y i/p :- In either y-t mode (or) X-Y mode the unknown test signal sensed using the probe of the ~~scope~~ cable is driven to y-i/p (or) vertical i/p). consider the test signal is sinusoidal.

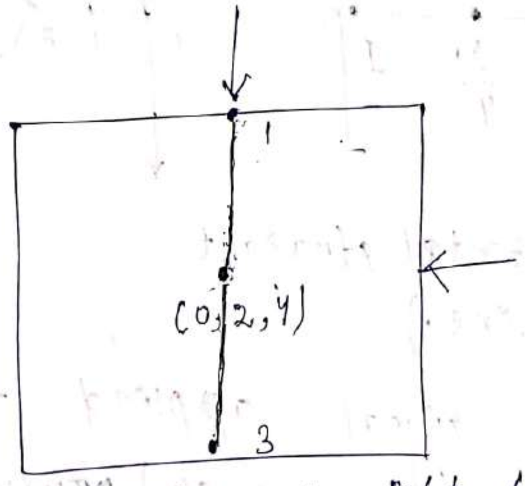
$V_y(t) = 2 \cdot \sin 314 t$

EX :-



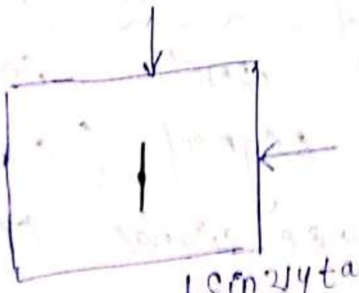
or 0.5 volt/cm

t	V_y
t_0	0
t_1	+2V
t_2	0
t_3	-2V
t_4	0

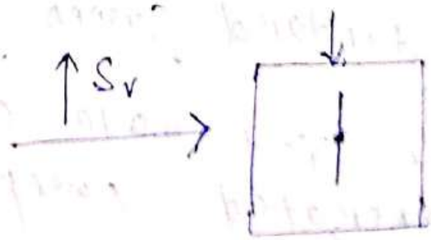


(vertical straight line)

EX:- 1·sin314t and 1 cm/volt



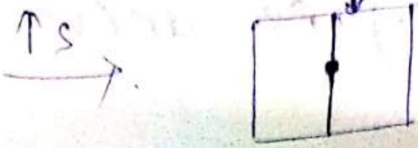
↑ Sv



1 sin314t and 2cm/volt

1 sin314t and 4 cm/volt

↑ s

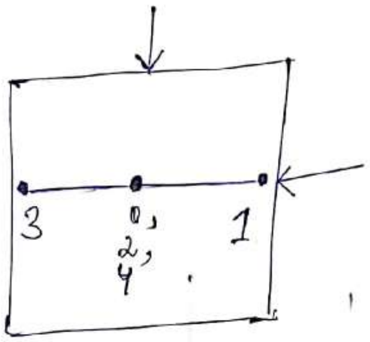


NOTE:- Any bipolar signal to Y-i/p produces vertical straight Line.

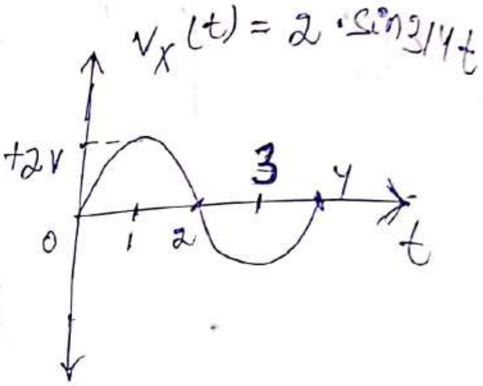
External signal to X-i/p:-

↳ In X-Y mode of oper^n any signal (known applied by user) via external horizontal i/p is driven to X-i/p of CRT. Consider the known external signal of sinusoidal signal

t	V_X
t_0	0
t_1	+2V
t_2	0V
t_3	(-2V)
t_4	0



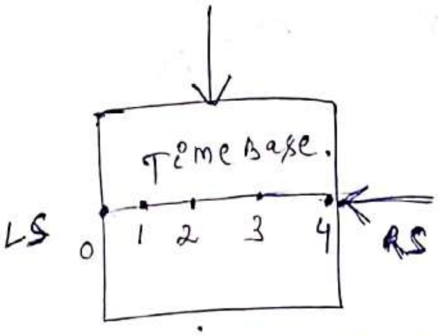
(Horizontal straight Line.)



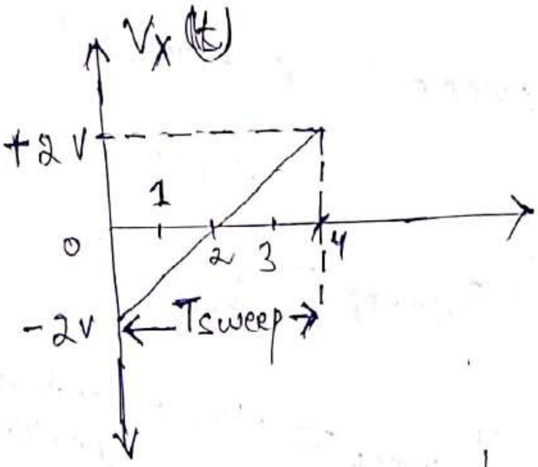
↳ Any bipolar signal applied to X-i/p (via external Horizontal i/p) produces horizontal straight Line.

↳ **standard sweep signal to X-i/p:-**

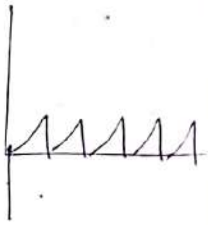
↳ In Y-t mode of oper^n internally generated sweep signal (sawtooth signal (or) Time Base signal or) Ramp signal (or) standard signal.) is driven to X-i/p.



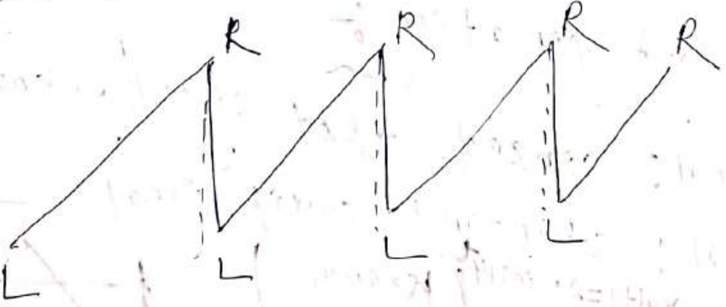
(Horizontal straight line.)



t	Vx
t0	-2 V
t1	-1 V
t2	0
t3	1 V
t4	2 V



↳ Due to the "sweep" applied to X - i/p, the spot (i.e. e^- beam) is swept across screen of CRO (L-R L-R L-R ....).

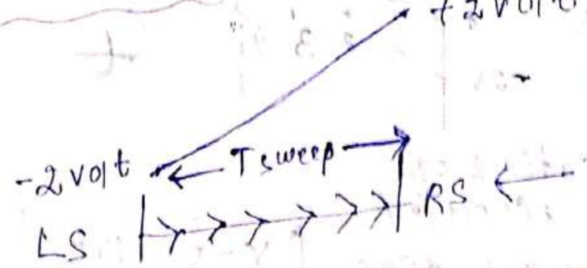


L to R : Trace

R to L : Retrace (or) fly back.

calculation of fsweep :-

Ex:



$\frac{1 \text{ ms}}{\text{div}}$

$T_{sweep} = 8$ Horizontal div × $1 \frac{ms}{div}$

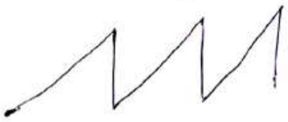
$= 8$ ms

∴ $f_{sweep} = \frac{1}{8 ms}$.

$\boxed{∴ T_{sweep} = \text{No. of Horizontal divisions} \times \frac{\text{TIME}}{\text{div}}}$

∴ and $\boxed{f_{sweep} = \frac{1}{T_{sweep}}}$

* $\frac{\text{TIME}}{\text{DIV}}$ ↑ ⟶ T_{sweep} ↑ ⟶ f_{sweep} ↓

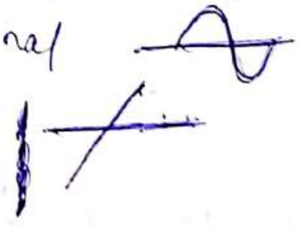


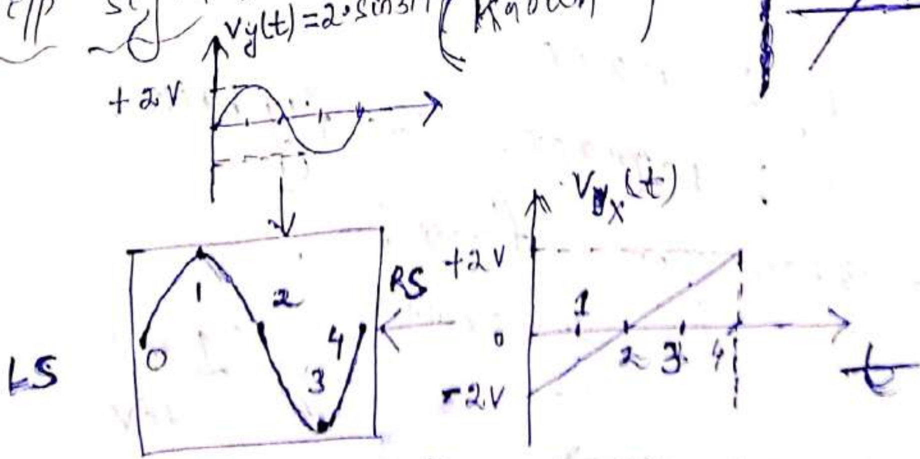
$\frac{\text{TIME}}{\text{DIV}}$ ↓ ⟶ T_{sweep} ↓ ⟶ f_{sweep} ↑

y-t mode of operation :-

↳ Y-i/p signal : sensed test signal (unknown)

X-i/p signal : standard sweep signal (Known)





Amplitude variations of Y-i/p signal displayed on screen w.r.t. time (Y-t plot)

t	Vx	Vy
t_0	(-2V)	0
t_1	(-1V)	+2V
t_2	0	0
t_3	+1V	(-2V)
t_4	+2V	0

T

$$f_{signal} = f_{sweep}$$

$$\Rightarrow T_{signal} = T_{sweep}$$

Measurements using Y-t plot :-

(i) peak to peak voltage measurements :-

$$\boxed{V_{p-p} = N_v \times \frac{VOLT}{DIV}}$$

where, V_{p-p} = p-p voltage of test signal.

N_v = Number of vertical divisions occupied between 2 peaks of test signal displayed.

$\frac{VOLT}{DIV}$ = Y-scale control setting.

(ii) peak voltage measurement :-

$$\boxed{V_p = \frac{V_{p-p}}{2}}$$

where V_p = peak voltage (or) Amplitude of test signal.

* V_{rms} and V_{dc} of test signal can also be measured, ~~based~~ based on waveform.

(iii) TIME PERIOD MEASUREMENT :-

$$\boxed{T_{signal} = \underset{per\ cycle}{N_H} \times \frac{Time}{div}}$$

where,

T_{signal} = Time period of test signal.

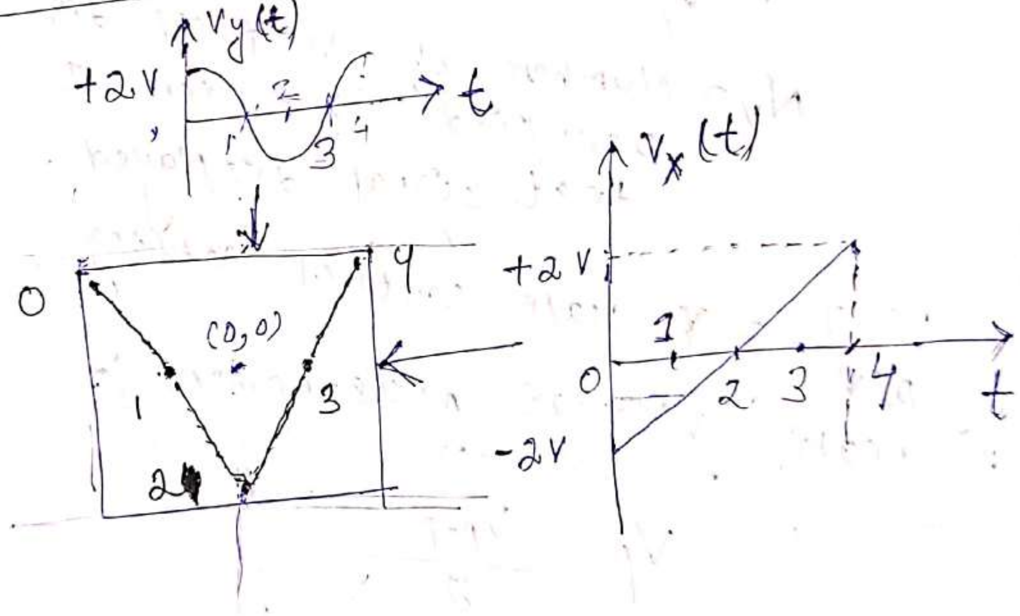
N_H percycle = No. of Horizontal divs. occupied by 1 cycle of test signal displayed.

$\frac{\text{TIME}}{\text{DIV}}$ = X - scale control setting

(iv) frequency measurement :-

$$\boxed{f_{signal} = \frac{1}{T_{signal}}}$$

EX :-



$$\frac{f_{signal}}{f_{sweep}} = 1$$

t	v_x	v_Y
t_0	-2V	+2V
t_1	-1V	0
t_2	0	-2V
t_3	+1V	0
t_4	+2V	+2V

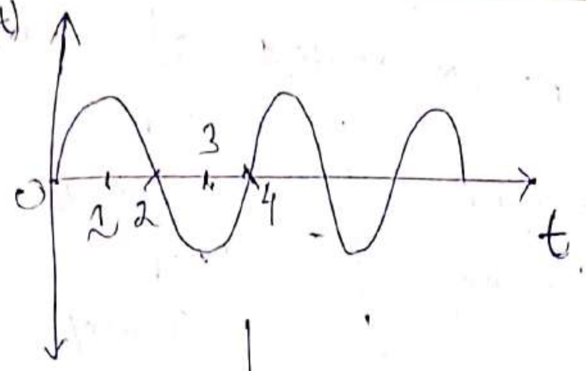
T

$\rightarrow T_{signal} = T_{sweep}$

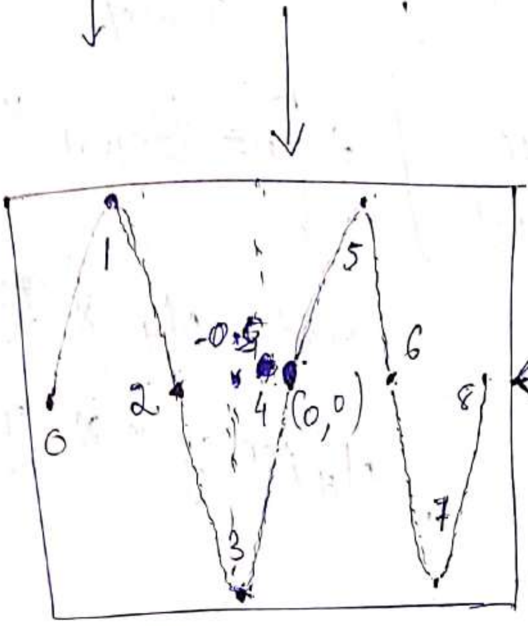
Ex :-

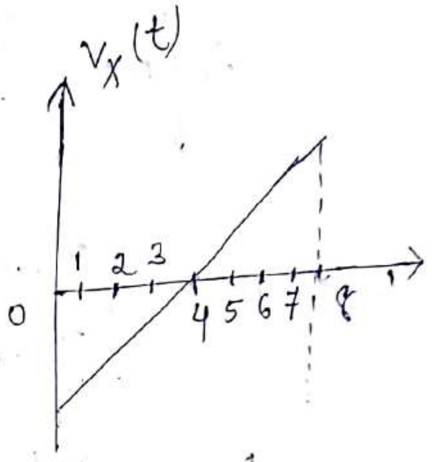
① 0.5 volt/div

= 2 div/volt



$f_{signal} = 2 \times f_{sweep}$





2 cycles of Y - i/p signal displayed.

V_X	V_Y
-2V	0
-1.5V	+2V
-1V	0
-0.5V	-2V
0V	0
0.5V	(+2V)
1V	0
1.5V	(-2V)
2V	0

$T_{sweep} = 2 \cdot T_{signal}$

NOTE :- whatever be the portions of Y i/p signal (test signal) existing with in one cycle of sweep will be super imposed onto the screen of CRO. and the no. of cycles of signal displayed on the screen will be = Ratio of signal freq^n to sweep frequency.

↳ say, 'n' is no. of cycles of signal displayed

$$\boxed{n = \frac{f_{signal}}{f_{sweep}}} = \frac{\frac{1}{T_{signal}}}{\frac{1}{T_{sweep}}}$$

$$\Rightarrow \boxed{n = \frac{T_{sweep}}{T_{signal}}} \Rightarrow \boxed{n = f_{signal} \times T_{sweep}}$$

$$\hookrightarrow n = \frac{T_{sweep}}{T_{signal}} = \frac{\text{Total } N_H \times \frac{TIME}{DIV}}{N_H \text{ per cycle} \times \frac{TIME}{DIV}}$$

$$\Rightarrow \boxed{n = \frac{\text{Total } N_H}{N_H \text{ per cycle}}}$$

$$\boxed{f_{signal} = n \cdot f_{sweep}}$$

where $n \geq 1$

$$\boxed{\text{i.e. } f_{signal} \geq f_{sweep}} \leftarrow \text{synchronization Relation}$$

{ minimum signal frequency = sweep frequency }

— x —

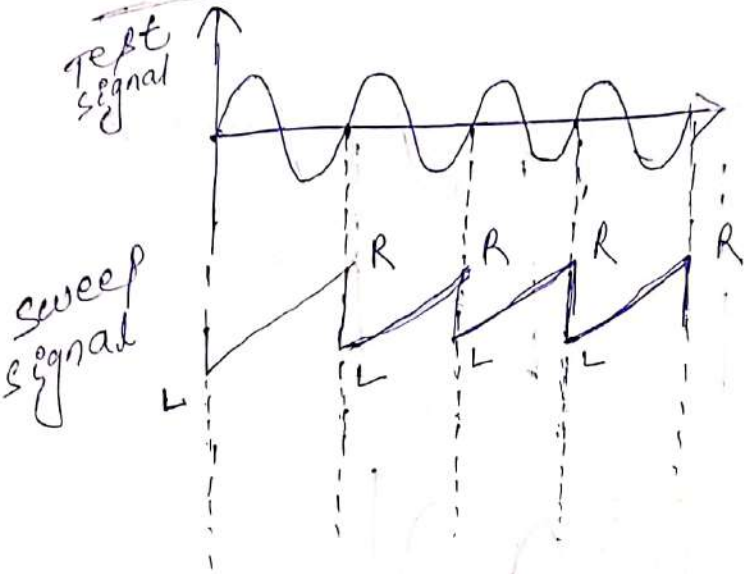
Que:

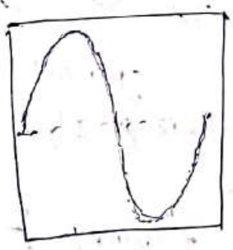
Find the images displayed on the screen when an analog, single channel oscilloscope is used to test a sinusoidal signal. Consider the below conditions,

(i) $f_{signal} = f_{sweep}$ (ii) $f_{signal} = 2 \cdot f_{sweep}$ (iii) $f_{signal} = 1.5 f_{sweep}$ (iv) $f_{signal} = \frac{3}{4} f_{sweep}$ (v).

Draw the test signal, sweep signal and image displayed on the screen.

sol^n. (i) $f_{signal} = f_{sweep}$:-

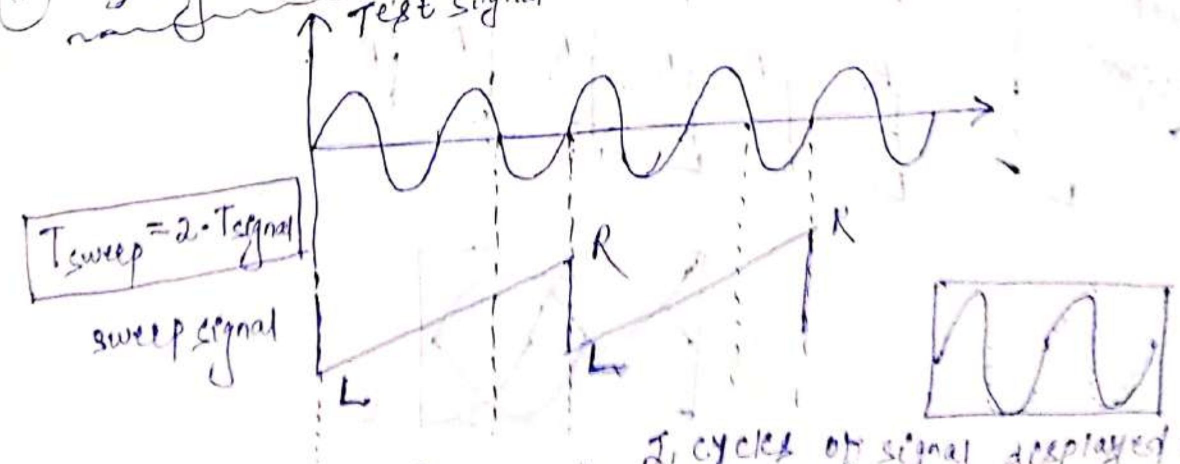




1 cycle of signal displayed which is steady image.

$\left(\therefore \frac{f_{signal}}{f_{sweep}} = 1\right)$

(ii) $f_{signal} = 2 f_{sweep}$:-



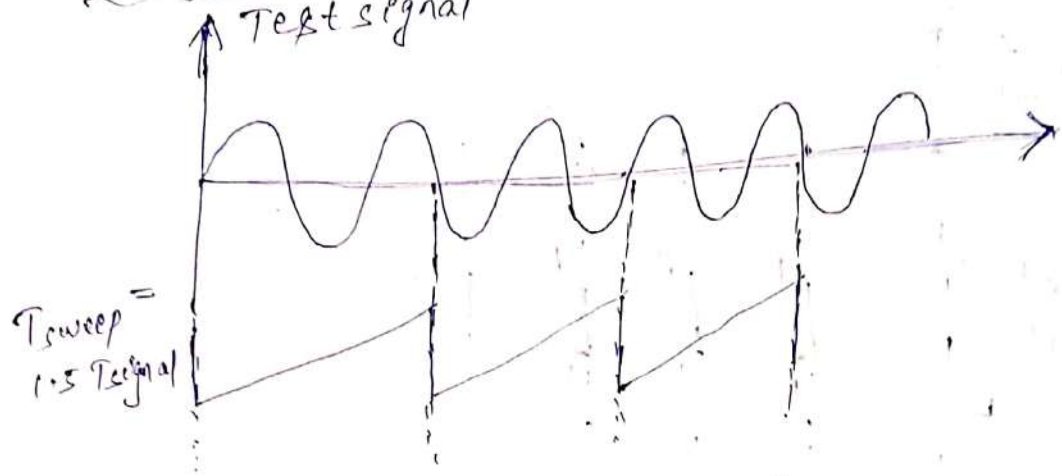
$\boxed{T_{sweep} = 2 \cdot T_{signal}}$

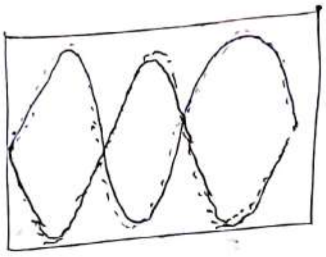
2 cycles of signal displayed which is steady image.

$\left(\therefore \frac{f_{signal}}{f_{sweep}} = 2\right)$

(∵ same 2 cycles repeatedly displayed)

(iii) $f_{signal} = 1.5$ sweep :-

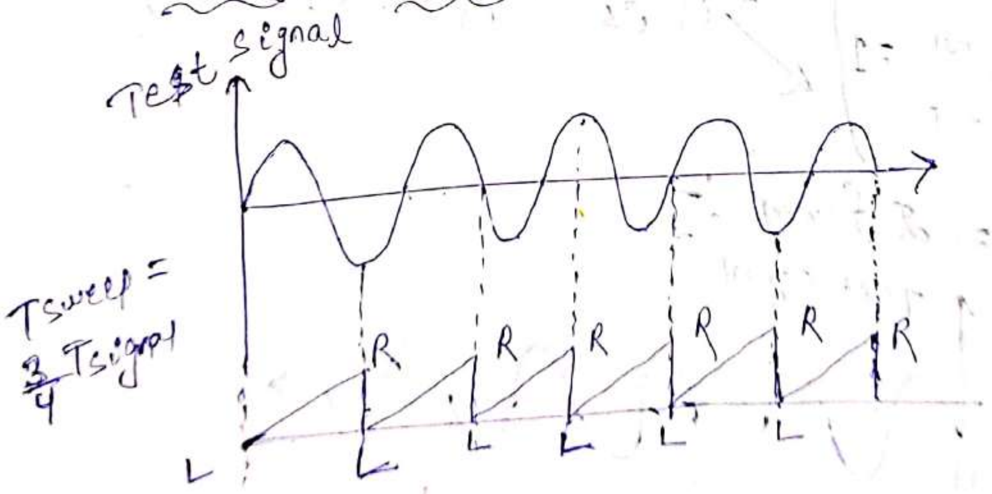


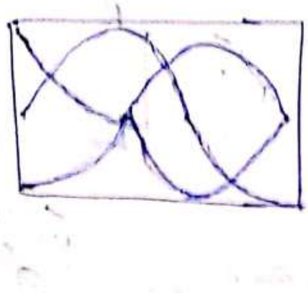


Jumble

Different 1.5 cycles of signal displayed on the screen.

(iv) $f_{signal} = \frac{3}{4} f_{sweep}$:-

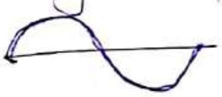




X-Y mode of operation :-

↳ In this mode the sensed test signal is driven to Y-i/p & any signal externally applied via external horizontal i/p is driven to X-i/p.

↳ Y-i/p signal :- sensed test signal (unknown)



X-i/p signal :- external signal (known)

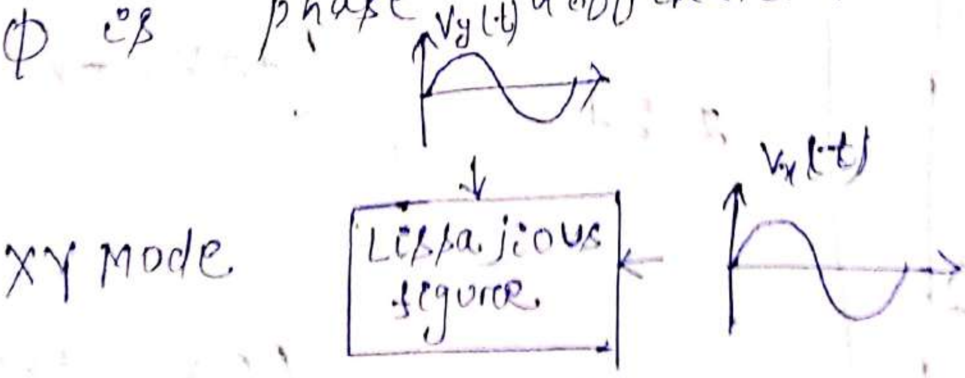
i.e. $V_y(t) = V_Y \cdot \sin(2\pi f_y t + \phi)$

$V_x(t) = V_X \cdot \sin(2\pi f_x t)$

where V_Y and V_X are amplitude of both signals. f_y is vertical frequency.

f_X is horizontal frequency.

ϕ is phase difference.



X-Y plot

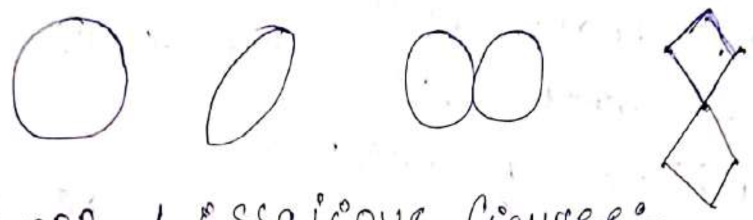
→ 2. basic measurements can be carried out using Lissajious figures :

① frequency measurement (f_y)

② phase measurement (ϕ)

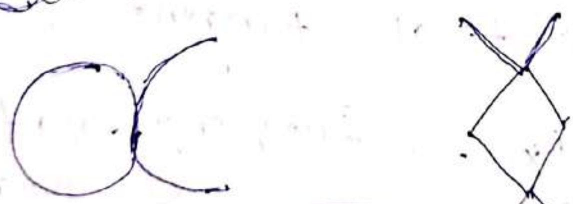
→ 3 types of Lissajious figures

closed Loop Lissajious figures :-

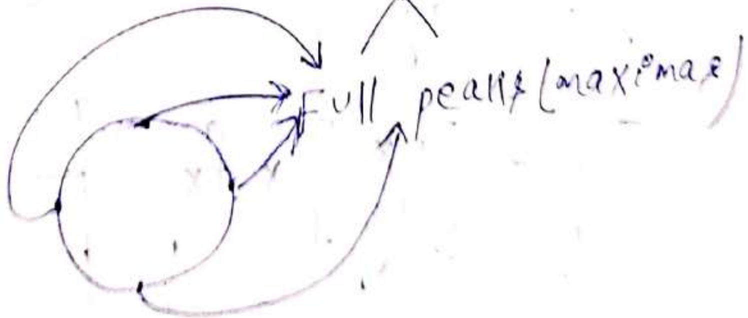


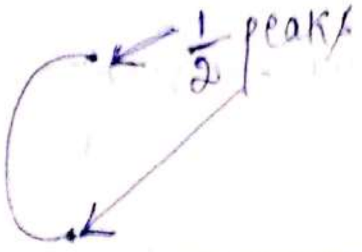
open Loop Lessajious figures :-

Mixed Lissajious figures :-



Note:-





frequency measurements using Lissajious Figures :-

↳ There are 2 method for this measurement namely ① Tangent method . and ② intersection method .

① **Tangent method :-** For given Lissajious figures, draw both horizontal and vertical tangent lines touching the peaks of Lissajious figure.

↳ Count no. of peaks as touch by both horizontal and veretical lines.

say, n_x = no. of peaks as touch by horizontal tangent line.

n_y = no. of peaks as touch by vertical tangent line.

Then,
$$\boxed{\frac{f_y}{f_x} = \frac{n_x}{n_y}}$$
... frequency-ratio measurement.

$$\boxed{\underbrace{f_y}_{\text{unknown frequency}} = \underbrace{\left[\frac{n_x}{n_y}\right]}_{\text{RATIO}} \times \underbrace{f_x}_{\text{known frequency}}}$$
— frequency measurement

(c) Intersection Method:

→ For the given lissajious figure, draw both horizontal and vertical lines passing through the lissajious figure.

→ Count no. of cuts as made by both horizontal and veretical lines.

say, n_x = no. of cuts as made by horizontal line.

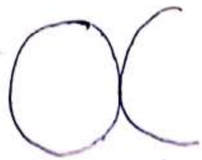
n_y = no. of cuts as made by vertical line..

↳ Then, $\boxed{\frac{f_y}{f_x} = \frac{n_x}{n_y}}$ ...... frequency ratio measurement

$\boxed{f_y = \frac{n_x}{n_y} \times f_x}$ ...... frequency measurement

NOTE:- Never draw a line via preexisting intersection.

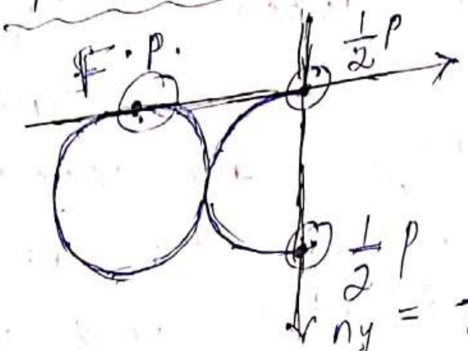
Ques:- ~~A-Q-RSA~~ Two sinusoidal signals having frequencies f_y and f_x are applied to veretical and horizontal input of an oscilloscope. The below given Lissajious figure is observed on screen.



① calculate what is the Ratio of vertical frequency to horizontal frequency.

② what is the vertical frequency when horizontal frequency is 1000 Hz.

Sol^n: TOUCH TECHNIQUE :



$n_x = 1 + \frac{1}{2}$
$= 3/2$

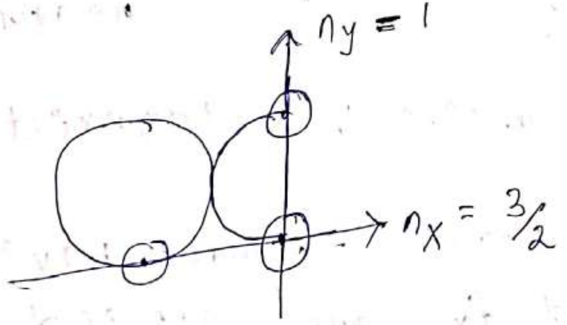
$n_y = \frac{1}{2} + 1/2 = 1$

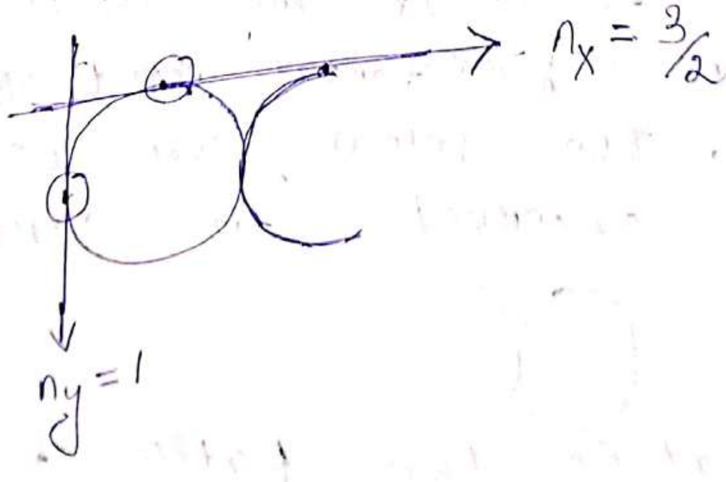
→ Draw both horizontal and vertical lines touching the peaks.

↳ $\frac{f_y}{f_x} = \frac{n_x}{n_y} = \frac{3/2}{1} = \boxed{3/2}$

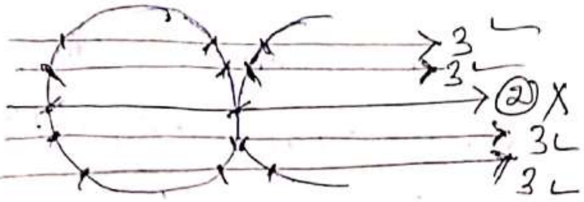
i.e. $f_y : f_x = 3 : 2$

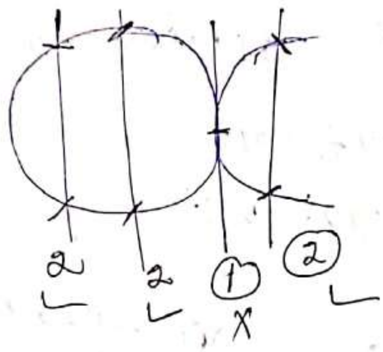
→ $f_y = 3/2\, f_x = \frac{3}{2} \times 1\ KHz$
$= 1.5\ KHz$





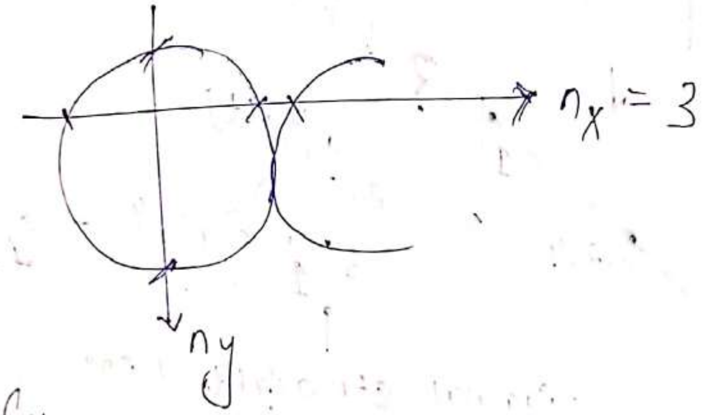
cut Technique :-





n_y = No. of cuts by vertical Line
= 2

n_x = No. of cuts by Horizontal Line.
= 3



$$\frac{f_y}{f_x} = \frac{n_x}{n_y} = 3/2$$

$$f_y : f_x = 3 : 2 \Rightarrow f_y = \frac{3}{2} f_x = \frac{3}{2} \times 1 \text{ KHz}$$

$$= \boxed{1.5 \text{ KHz}}$$

— x —

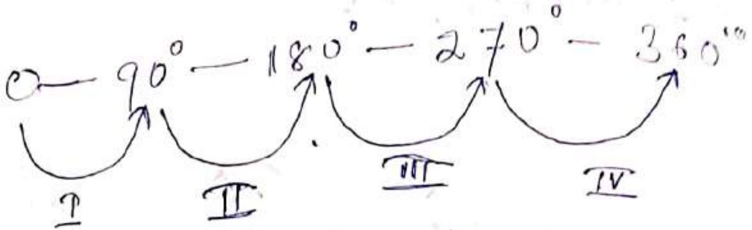
phase measurement using Lissajious figures :-

consider, two sinusoidal signals having equal amplitudes and equal frequencies but differing in phase by ~~π~~ φ ~~by~~ are applied to both i/ps of CRO.

i.e. $V_y(t) = V \cdot \sin(2\pi f t + \phi)$

$V_x(t) = V \cdot \sin(2\pi f t)$

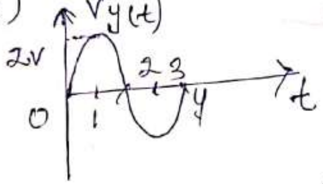
$\phi = ?$



CASE - I :- 2 sinusoidal signals having equal amplitude $V_Y = V_X$, $f_y = f_X$ and $\phi = 0°$ (or) $360°$, are applied to both inputs of CRO.

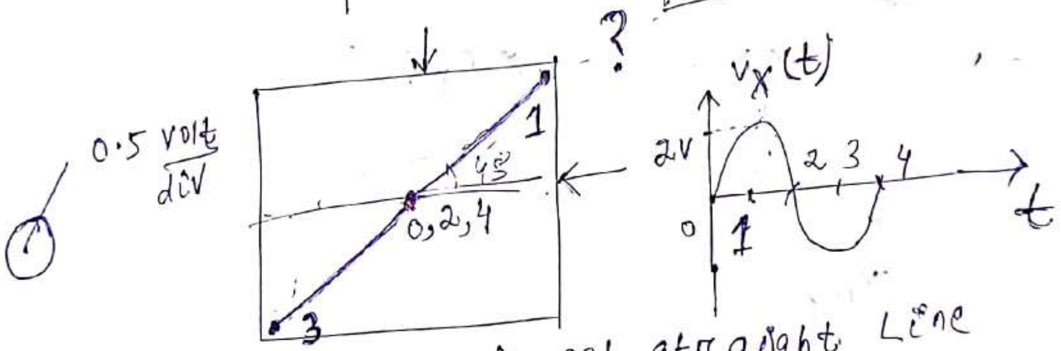
i.e. $V_y(t) = 2 \cdot \sin 314t$ volt

$V_X(t) = 2 \cdot \sin 314t$ volt



in-phase

$\boxed{\phi = 0° \text{ (or) } 360°}$

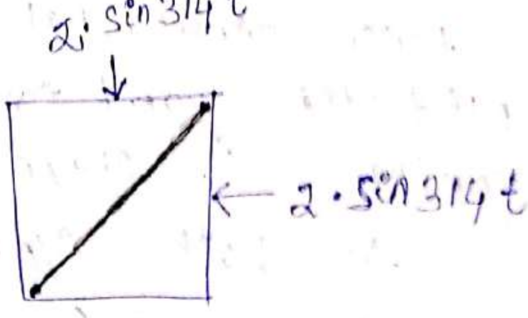


Diagonal straight Line (making 45° with (+ve) x-axis)

((or) making 135° with (-ve) x-axis)

t	V_X	V_Y
t_0	0	0
t_1	+2V	+2V
t_2	0	0
t_3	(-2V)	(-2V)
t_4	0	0

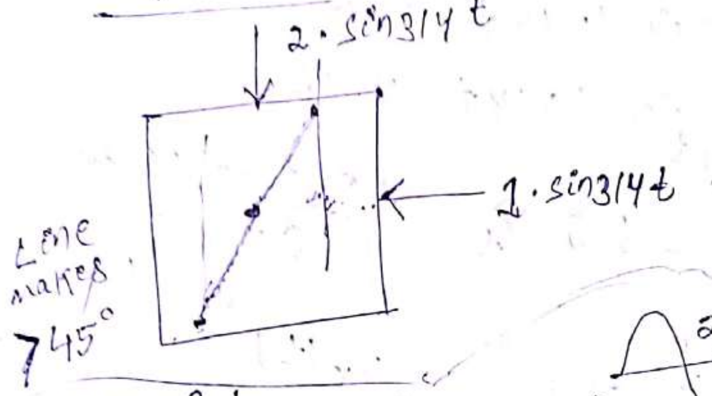
NOTE-1 :-



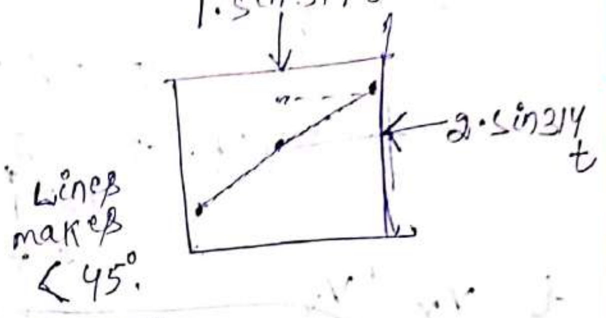
$f_y = f_x$

$\phi = 0^\circ$

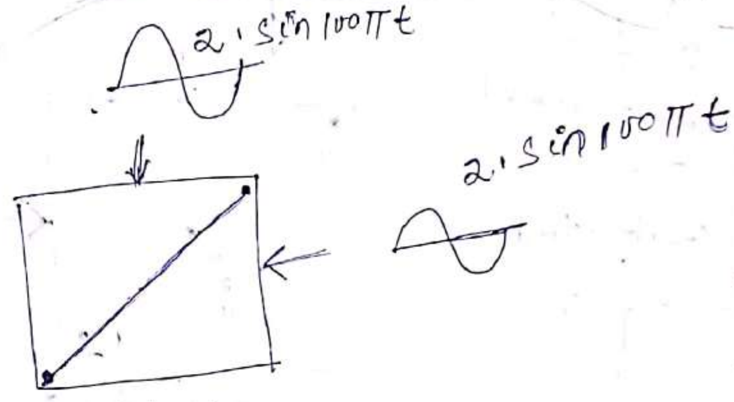
$V_Y > V_X$



$V_Y < V_X$



NOTE-2 :-



$V_y = V_x$

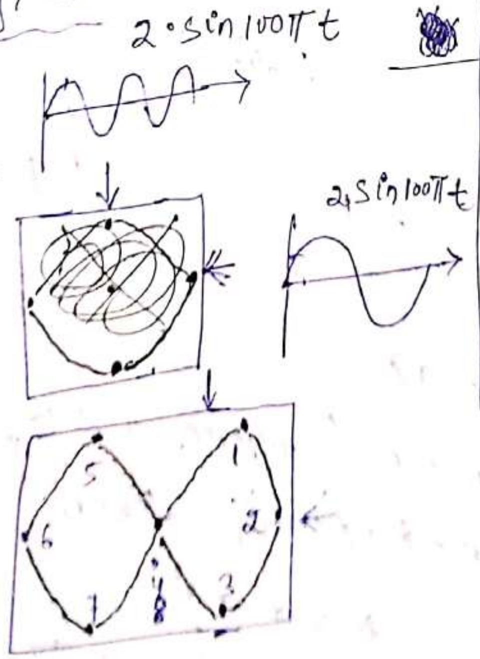
$f_y = f_x$

$\phi = 0^\circ$

$V_Y = V_X$

$\phi = 0^\circ$

$f_y > f_x$

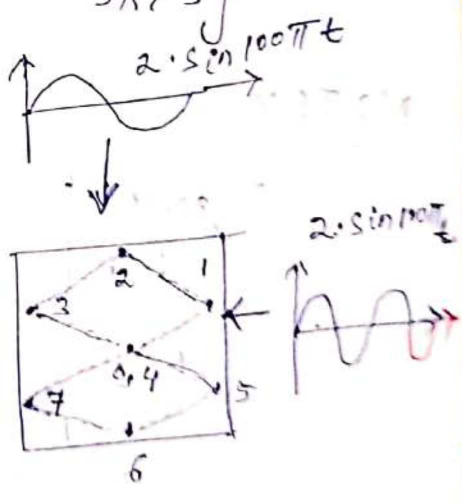


V_X	V_Y
0	0
+1V	+2V
+2V	0
+1V	(-2V)
0	0
-1V	+2V
-2V	0
-1V	(-2V)
0	0

$\frac{f_y}{f_x} = 2 : 1$

V_X	V_Y
0	0
2	1
0	2
-2	1
0	0
2	(-1)
0	(-2)
-2	(-1)
0	0

$f_X > f_Y$



$\frac{f_y}{f_X} = 1 : 2$

CASE-2 :- 2 sinusoidal signals having $V_Y = V_X$, $f_y = f_X$ and $\phi = 180°$ are applied to both ~~i/ps~~ inputs of CRO ;

i.e. $V_y(t) = 2\cdot\sin(314t + 180°)$

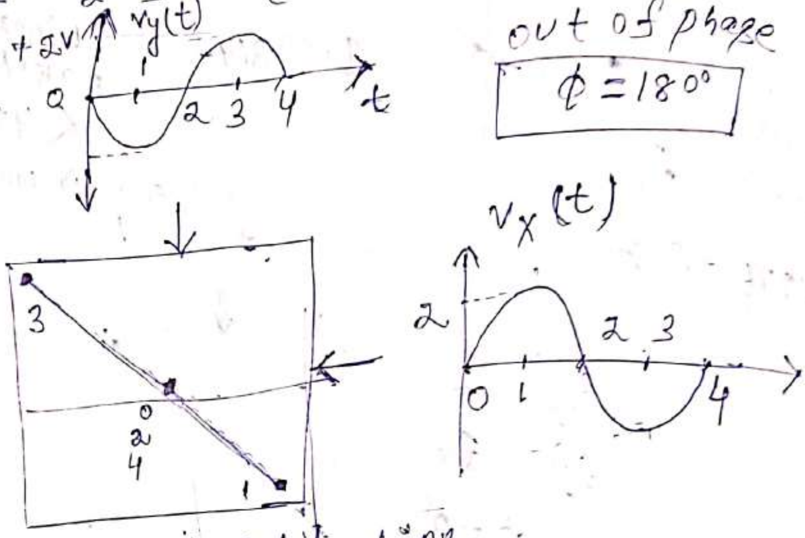
$= -2\cdot\sin(314t)$ volt

$V_X(t) = 2\cdot\sin(314t)$ volt

out of phase

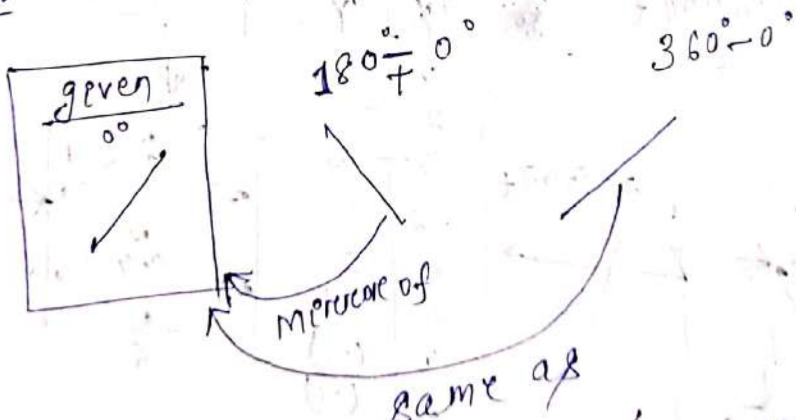
$\boxed{\phi = 180°}$

t	V_X	V_Y
t_0	0	0
t_1	2V	(-2V)
t_2	0	0
t_3	(-2V)	+2V
t_4	0	0



Diagonal straight line making 135° with +ve X-axis, (or) making 45° with -ve X-axis.

NOTE:-



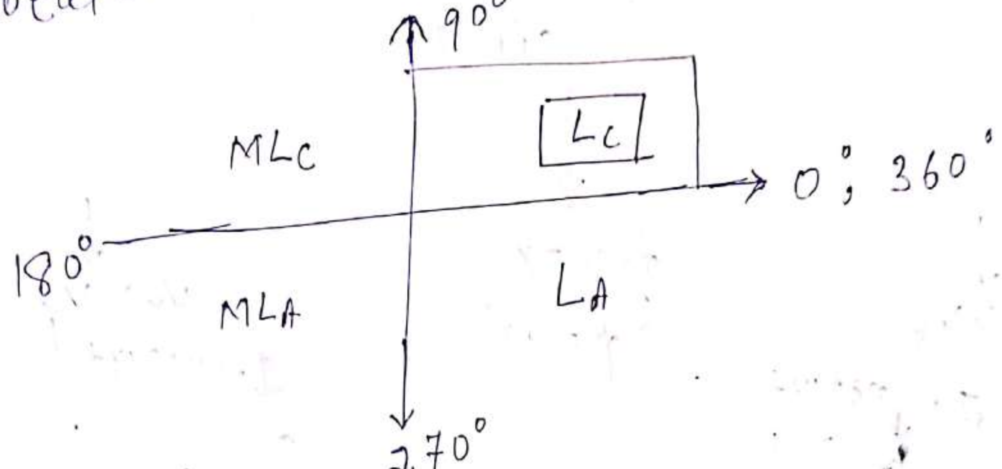
LF = Lissajous figure

↳ If LF[ϕ_X] is known (where $0° < \phi_X < 90°$ and clkwise to rotation) then following conclusions can be made:

(i) LF[$180° - \phi_X$] is mirror of LF[ϕ_X] and rotation - clkwise.

(ii) LF[180° + ϕ_X] is mirror of LF[ϕ_X] and rotation - Anticlockwise.

(iii) LF[360° - ϕ_X] is same as LF[ϕ_X] and rotation - Anticlockwise.



0° - 180° : LF rotation in clockwise.

180° - 360° : LF rotation in Anticlockwise.

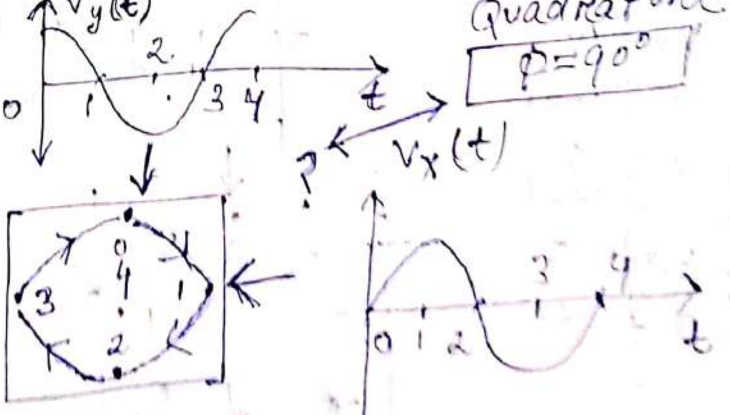
CASE 3 :- 2 sinusoidal signals having $V_Y = V_X$, $f_y = f_X$ and $\phi = 90°$ are applied to both inputs of CRO.

i.e. $v_y(t) = 2 \cdot \sin(314t + 90°)$

$= 2 \cdot \cos 314t$ volt

$V_X(t) = 2 \cdot \sin(314t)$ volt

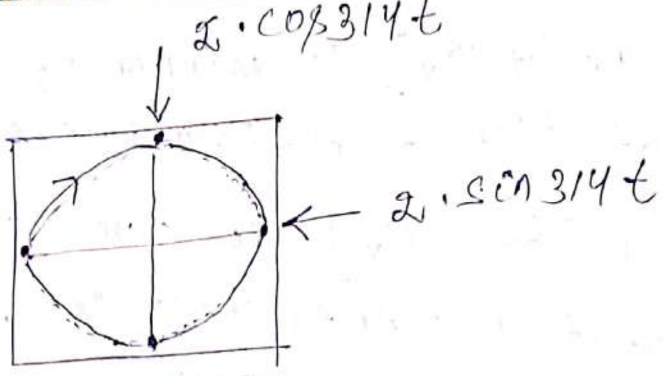
t	V_X	V_Y
t_0	0	+2
t_1	2	0
t_2	0	(-2 V)
t_3	-2V	0
t_4	0	2V



circle
clock-wise
Rotation

NOTE:-

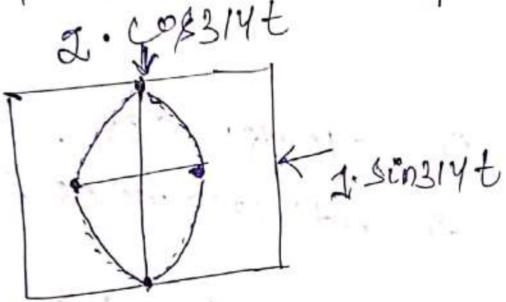
$V_y = V_x$
$f_y = f_x$
90°



circle

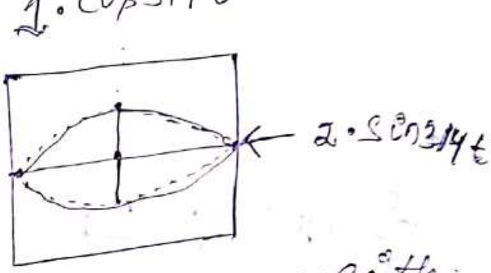
$f_y = f_x$
$\phi = 90°$

$V_y > V_x$



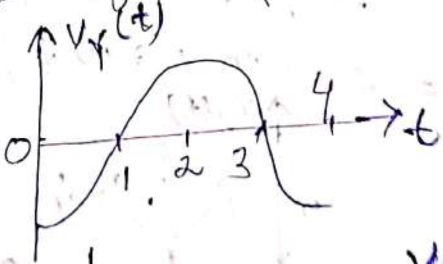
Ellipse with Y axes as major axes.

$V_x > V_y$

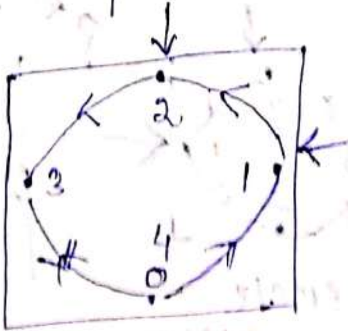


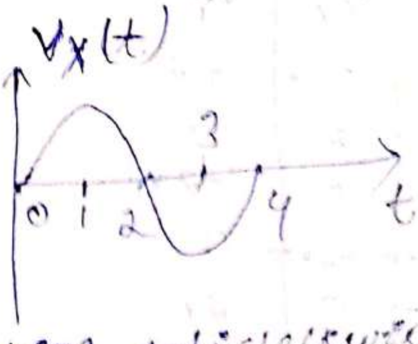
Ellipse with X-axis as major axis

CASE-4:- 2 sinusoidal signals having $V_y = V_x$, $f_y = f_x$ and $\phi = 270°$ are applied to both i/ps of CRO.



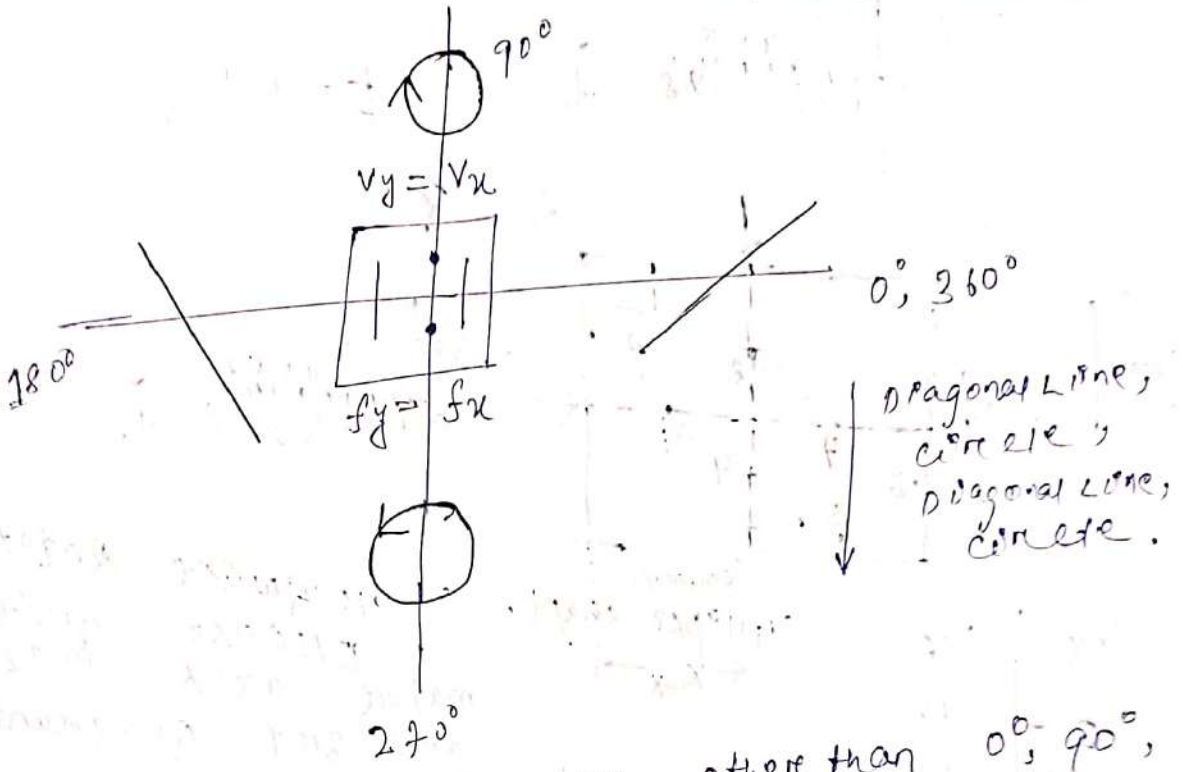
t	Vx	Vy
t0	0	(-2V)
t1	2	0
t2	0	(+2)
t3	(-2V)	0
t4	0	(-2V)





circle Rotating Anticlockwise

Note: Conclusions w.r.t. cases 1, 2, 3 and 4:



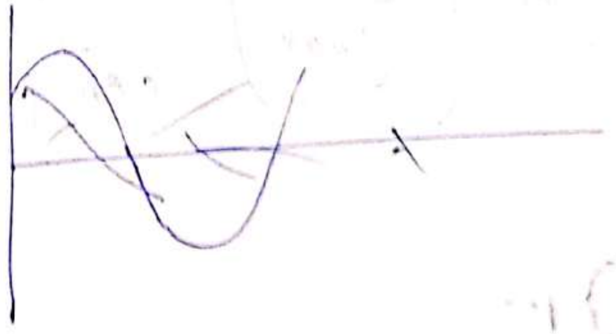
for any phase difference other than 0°, 90°, 180°, 270° and 360°, the Lisajious figure displayed on the screen will be ← .

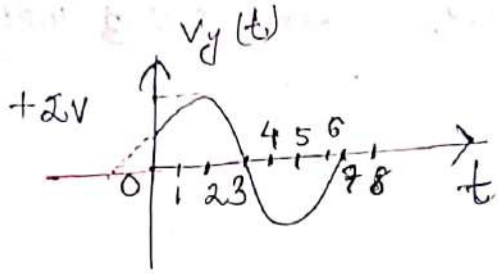
conc:- Ellipse.

CASE-5:- 2 sinusoidal signals having $f_y = f_X$ and $0° < \phi_X < 90°$, $V_Y = V_X$; to both i/ps of CRO. are applied

i.e. $V_y(t) = 2 \cdot \sin(314t + 45°)$

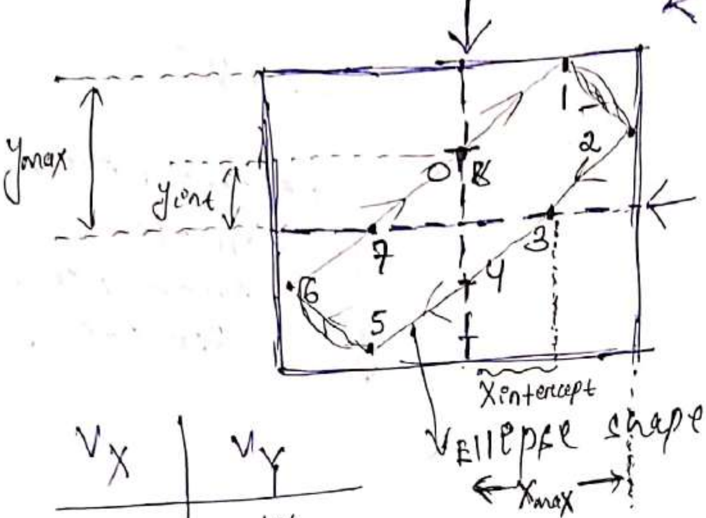
$V_X(t) = 2 \cdot \sin 314t$

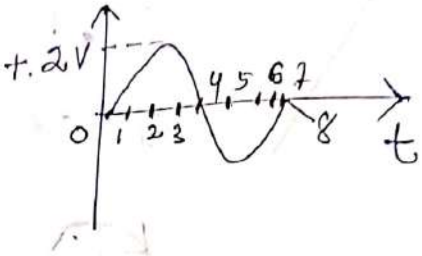




$$\boxed{\phi = 45^\circ}$$

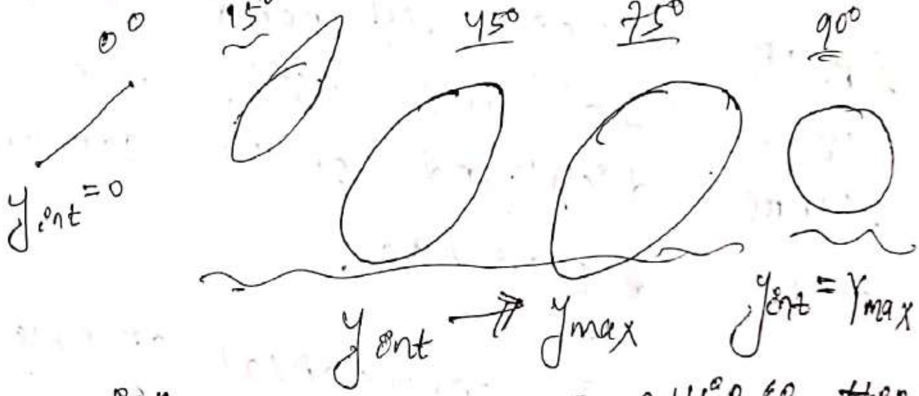
?





clockwise Rotating Ellipse with major axis in 1st and 3rd quadrant.

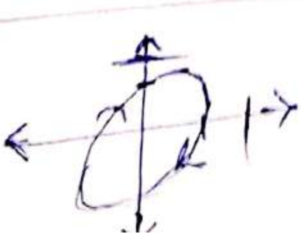
V_X	V_Y
0	1V
1V	2V
2V	1V
1V	0
0	-1V
-1	-2
-2	-1
-1	0
0	+1



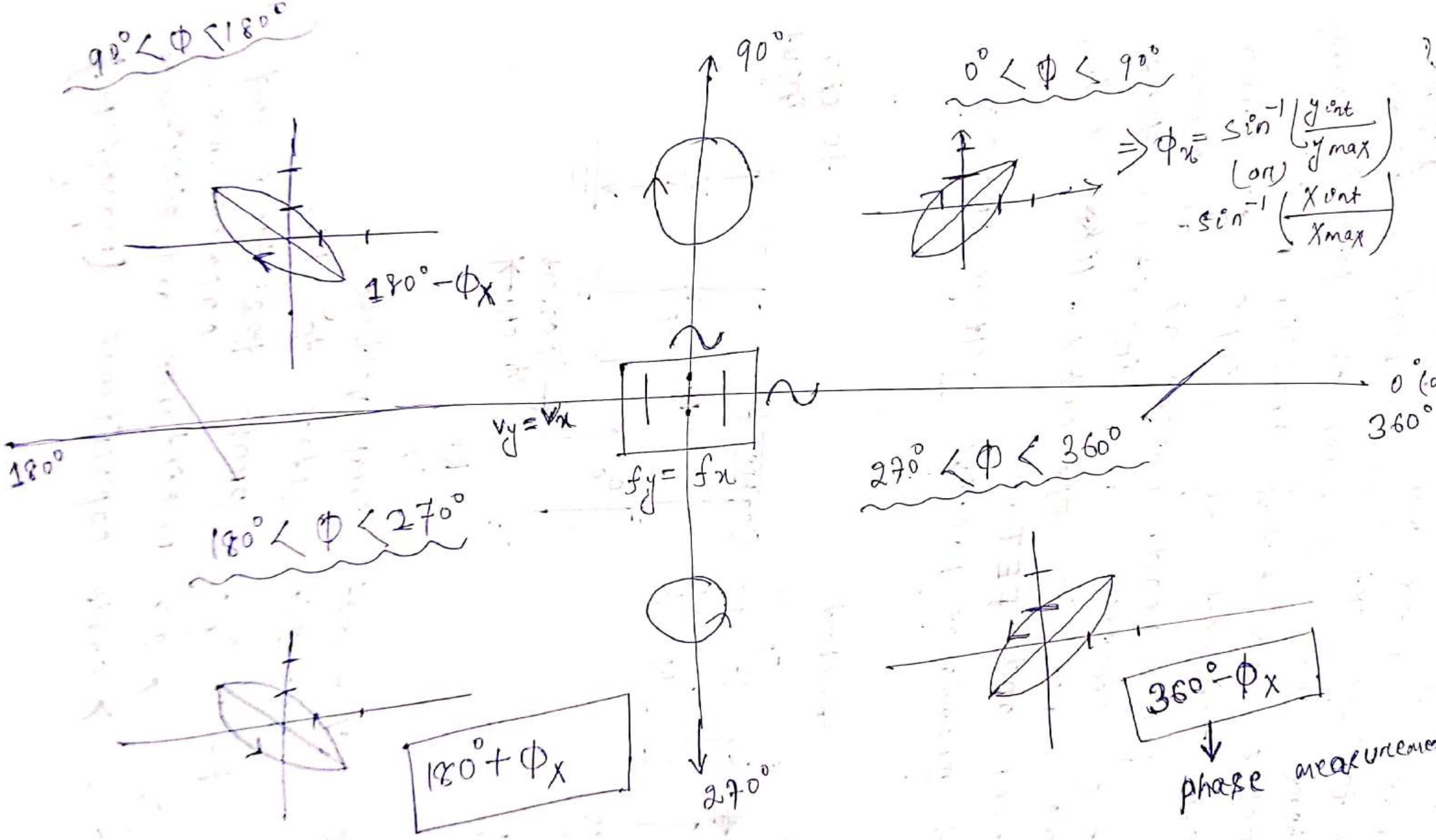
Line becomes ellipse then circle.

↳ For any given ellipse rotating in clkwise dirn and having major Axis in 1st and 3rd quadrant.

$$\boxed{\phi_X = \sin^{-1}\left(\frac{y_{int}}{y_{max}}\right) \quad \text{(or)} \quad \sin^{-1}\left(\frac{X_{int}}{X_{max}}\right)}$$



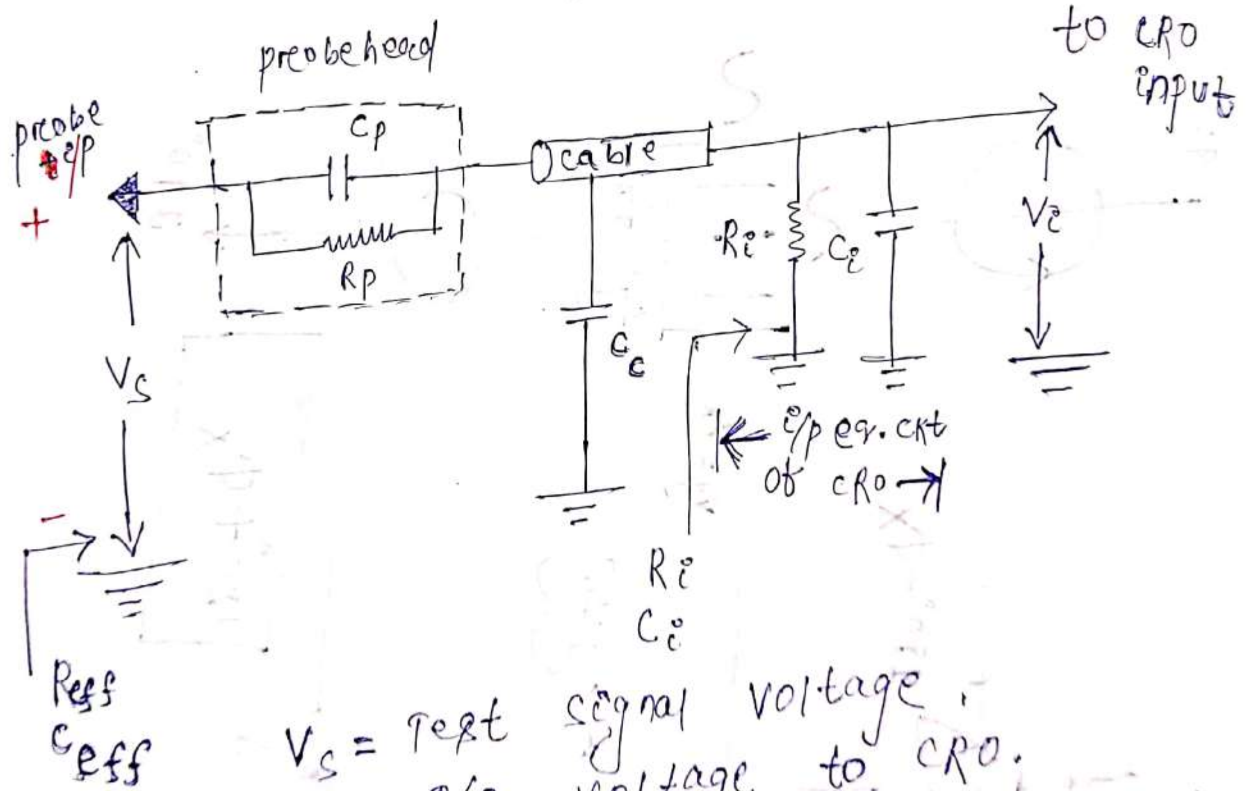
conclusion chart :-



$$\Rightarrow \phi_x = \sin^{-1}\left(\frac{y_{int}}{y_{max}}\right)$$
(or)
$$\sin^{-1}\left(\frac{x_{int}}{x_{max}}\right)$$

C.R.O. PROBES :- The probe is a connecting medium used for introducing the CRO in to the ckt. under test. Basically there are 2 types of probes. passive probes and Active probes. A passive probe consist of simple R-C n/w in the probe head. where as an active probe consists of circuitary that has active elements, like B.J.T, op-amp and FET.

High Impedance passive voltage probe :-



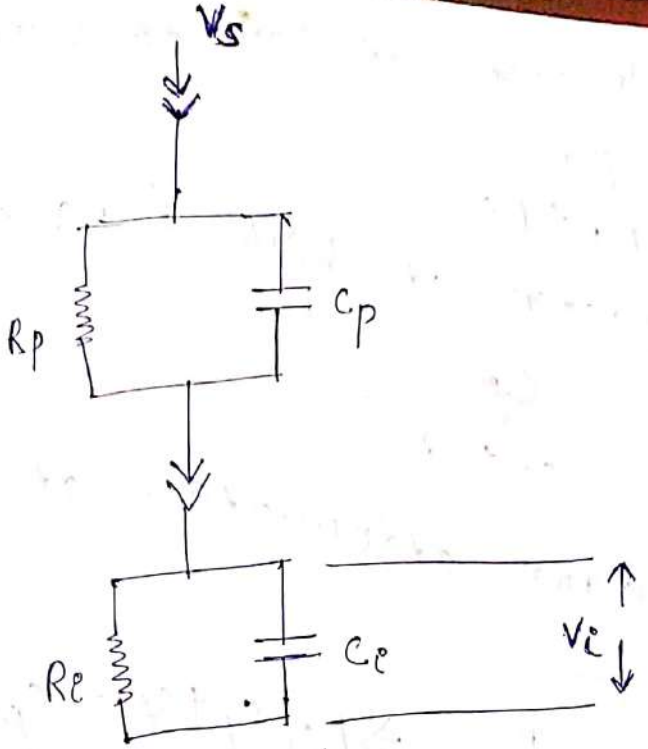
V_s = Test signal voltage.

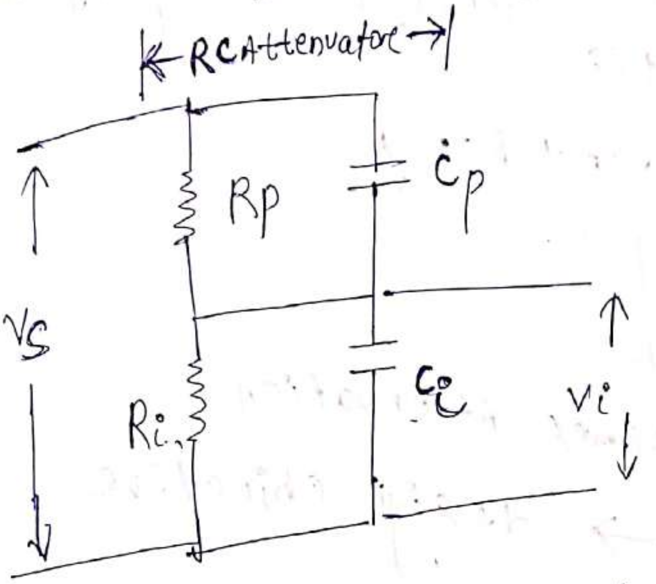
V_i = I/p voltage to CRO.

R_p and C_p → probe resistance and capacitance.

R_i and C_i → I/p resistance and capacitance

C_c → cable capacitance (negligible.)





$$\boxed{V_i = K V_s}$$

where K is Attenuation factor. (K<1)

At Low frequencies :- consider resistive loading,

$$\boxed{v_i = V_s \times \frac{R_i}{R_p+R_e}}$$

At High frequencies :- consider capacitive loading,

$$V_i = V_s \cancel{X} \cdot \frac{X_{ci}}{X_{cp}+X_{ci}} = V_s \cdot \frac{1/\omega c_i}{\frac{1}{\omega c_p}+\frac{1}{\omega c_i}}$$

$$= V_s \cdot \frac{1/\omega c_i}{\frac{c_i+c_p}{\omega c_i \cdot c_p}} \Rightarrow \boxed{V_i = V_s \cdot \frac{c_p}{c_p+c_i}}$$

↳ Attenuation factor at low frequency

$$= \frac{R_i}{R_p + R_i}$$

Attenuation factor at high frequency

$$= \frac{C_p}{C_p + C_i}$$

∴ To achieve same attenuation at all frequencies :-

$$\frac{R_i}{R_p + R_i} = \frac{C_p}{C_p + C_i} \Rightarrow R_i(C_p + C_i) = C_p(R_p + R_i)$$

$$\Rightarrow \cancel{R_i \cdot C_p} + R_i \cdot C_i = R_p \cdot C_p + \cancel{R_i \cdot C_p}$$

$$\Rightarrow \boxed{R_i \cdot C_i = R_p \cdot C_p}$$

Design case :- 10 times Attenuation

$$\hookrightarrow \frac{V_i}{V_s} = \frac{1}{10} \rightarrow \text{design objective}$$

Ques: To achieve 10 times attenuation what are the values of R_p and C_p to be selected by the designer.

Sol: $$\frac{V_i}{V_s} = \frac{R_i}{R_p + R_i} = \frac{C_p}{C_p + C_i} = \frac{1}{10}$$

$$\hookrightarrow \frac{R_i}{R_p + R_i} = \frac{1}{10} \Rightarrow R_p + R_i = 10 \cdot R_i$$

$$\Rightarrow \boxed{R_p = 9 \cdot R_i}$$

$$\frac{C_p}{C_p + C_i} = \frac{1}{10} \Rightarrow 10 \cdot C_p = C_p + C_i$$

$$\Rightarrow \boxed{C_p = C_i/9}$$

question: when above probe is used ~~by~~ then what is the effective i/p resistance, effective i/p capacitance and V_i.

sol^n: $R_{eff} = R_p$ in series with R_i

$$= R_p + R_i = 9R_i + R_i = \boxed{10R_i}$$

↳ i/p resistance increases by 10 times.

$C_{eff} = C_p$ in series with C_i

$$= \frac{C_p \times C_i}{C_p + C_i} = \frac{\frac{C_i}{9} \times C_i}{\frac{C_i}{9} + C_i} = \frac{C_i^2/9}{10 \cdot C_i/9} = \boxed{\frac{C_i}{10}}$$

input capacitance decreases by 10 times.

↳ $V_i = \frac{1}{10} \times V_s \Rightarrow \boxed{V_i = 0.1\, V_s}$

signal is attenuated by 10 times.

∴ This probe is known as 10 times probe. (OR) 10X probe (OR) 10:1 probe.

—— x ——

Design case :- N times Attenuation

Design criteria :- selection of "R_p and C_p" values

$$\frac{V_i}{V_s} = \frac{1}{N}, \quad R_p = (N-1)R_i$$

$$C_p = \frac{C_i}{N-1}$$

Uses :- N : 1 probe (or) N times probe (or) N x probe :-

$V_i = \frac{1}{N} \times V_s$, $R_{eff} = N \cdot R_i$, $C_{eff} = \frac{C_i}{N}$

↓ at probe tip

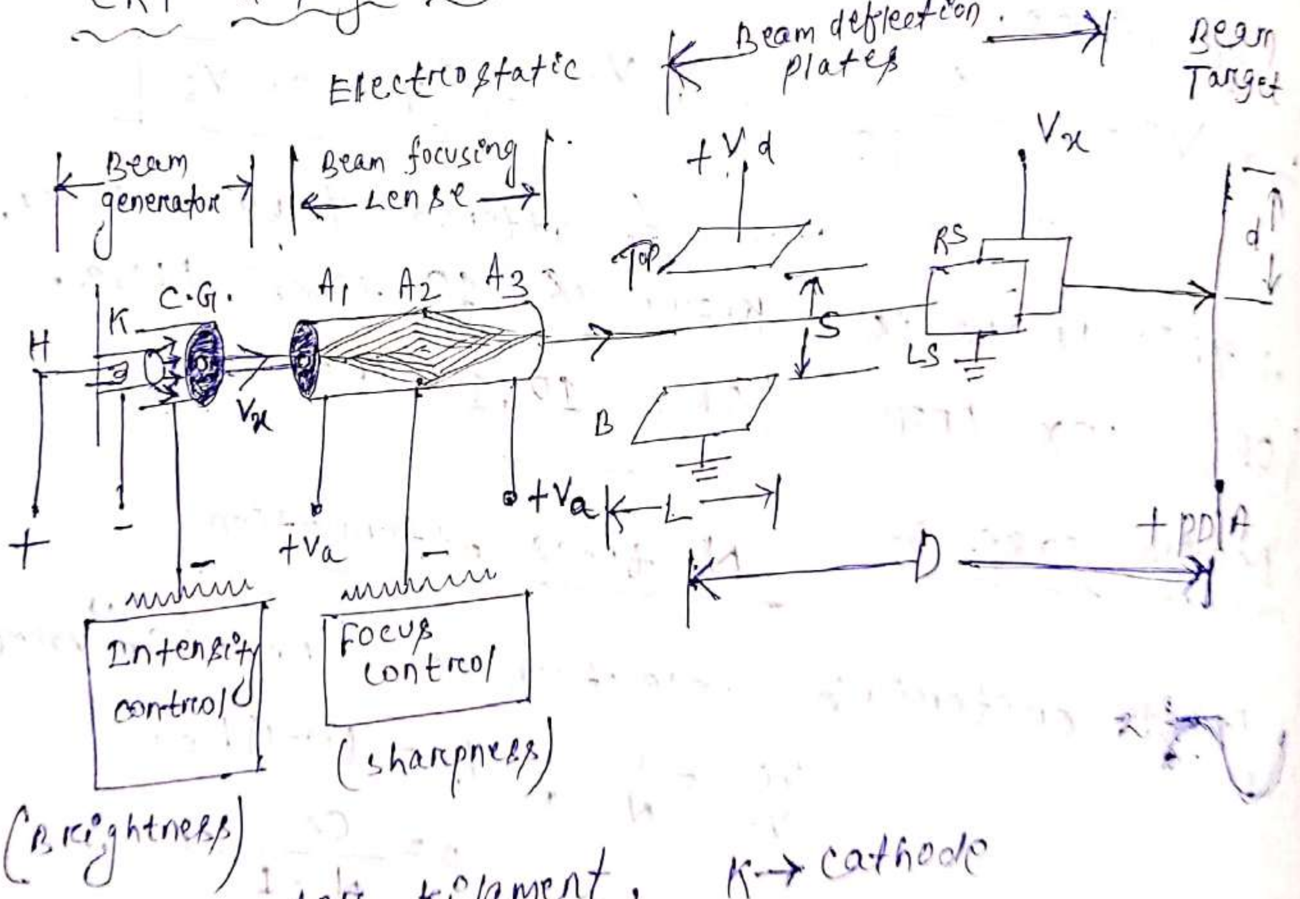
↳ 1:1 probe is a direct probe which is a simple test wire.

↳ probes can also be classified as voltage probes, current probes & logic probes.

↳ Active probes are expensive, much bulky and require external source for operation.

↳ passive probes ~~contain~~ (compensated probe) contain parallel RC network.

CRT design Details :- Electrostatic



H → Heater filament, K → cathode

CG → control grid ⊖ -ve (Intensity control)

A1 — 1st Accelerating Anode (or) pre Accelerating Anode

A2 — Focusing Anode.

A_3 — 2nd Accelerating Anode.

V_a — Accelerating Anode voltage.

$$\boxed{v_x = \sqrt{\frac{2 \cdot e \cdot V_a}{m}}}$$ = ~~ve~~ velocity of Accelerated electron beam.

V.D.P demensions : L = Length of VDP.

S = separation distance between VDPs.

D = Distance betn VDP and screen.

d = Amount of veretical deflection.

V_d = deflecting signal voltage (test signal)

$$\boxed{S_V = \frac{d}{V_d} = \frac{L \cdot D}{2\, S \cdot V_a}}$$ — veretical deflection sensitivity

PDA → post deflection Accelerating Anode (OR) Final Anode.

↳ cathode is a Nickel cylinder, held by (or) enclosed by control grid. when the heater heats the cathode indirectly electrons are evaporated from the metallic surface of cathode due to thermionic emission. These emitted electrons experience a repulsion force from the inner cylindrical side walls of control grid. since grid voltage is highly (-ve) w.r.t. cathode. The repulled electrons emerge out of the pin hole of control grid as a beam.

The number of electrons in the beam
i.e. intensity can be adjusted
by adjusting the grid voltage.
(The brightness of the image displayed
on the screen depends upon 3 factors.
namely types of phosphor coating given
on the backside of screen, velocity
of electron beam, and intensity of
electron beam. By adjusting grid
voltage the intensity of beam and
interm brightness of displayed image can be
adjusted by the user. It is called
intensity control.

↳ Electro static focusing lense comprises
of A1, A_2, and A_3 (also known as focal
Ring) the voltage applied to A_1 and A_3
is highly +ve (Anode voltage Va).
as such Due to high potential
difference A_1 and C.G. the electron
beam is immediately accelerated with
velocity Vx towards the
lense and enter via the pinhole
of A1. In the lense the electron
beam experiences various forces,
because of which it gets completely diverged
out and then converged in to a

sharp beam. The sharpness of the beam can be adjusted by adjusting A_g, voltage focusing anode voltage ~~kno~~. It is known as focus control. The velocity with which the ~~then~~ beam enters the lense will be the same velocity with which it leaves the lense. This electron beam accelerated, focused electron beam is then deflected vertically and horizontally left and up and down and right, due to the voltages ~~supplied~~ applied to VDPs and HDPs. This electron beam is once again accelerated with high velocity due to a very high (+ve) voltage ~~applied~~ attached to the screen.

Design issue:- $S_v \propto L$ → VDPs must be longer plates.

$\propto D$ → VDPs are are kept away from the screen.

$S_v \propto \frac{1}{S}$ → VDPs are kept close to each other.

$S_v \propto 1/V_a$ → Va must be kept low.

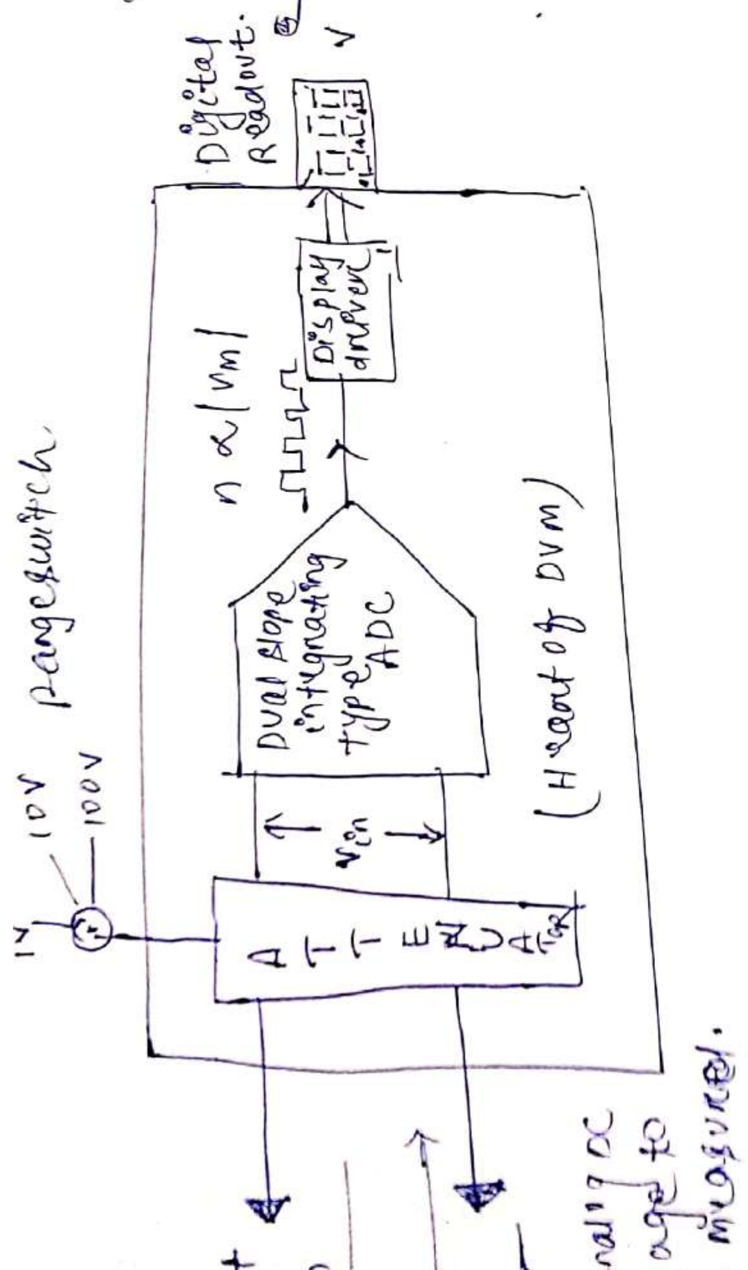
→ To achieve High sensitivity.

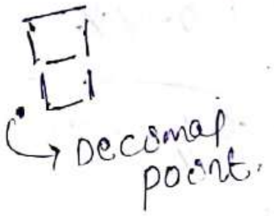
But if Va is kept low, then velocity of electron beam become low ($\because V_x \propto \sqrt{V_a}$) and ~~in turn~~ in turn brightness of displayed image become less. As such, to improve brightness e^- beam is accelerated one more time i.e. post to deflection with the help of PDA.

ELECTRONIC MEASUREMENT

Digital voltmeters (DVMs) :-

A DVM is truely a voltage measuring unit. The unknown analog DC voltage (to be measured) is first converted into digital form. (with the help of ADC), and then displayed on a digital readout. (It consist a no. of ~~seg~~ seven segment digit.)





Ex: A 4 digit, 10V fullscale dual slope integrating DVM.

DVM = ADC + dd + D

Resolution of DVM :- The smallest possible incremental change allow at the i/p voltage is known as resolution of DVM. Resolution is nothing but minimum count (or) one count (or) 1st count (or) 1st step.

$$\boxed{r = \frac{1}{10^N}}$$

where, N = No. of full digits.

10^N = Basic scale, r = scale resolution.

→ Resolution of DVM in selected voltage range.

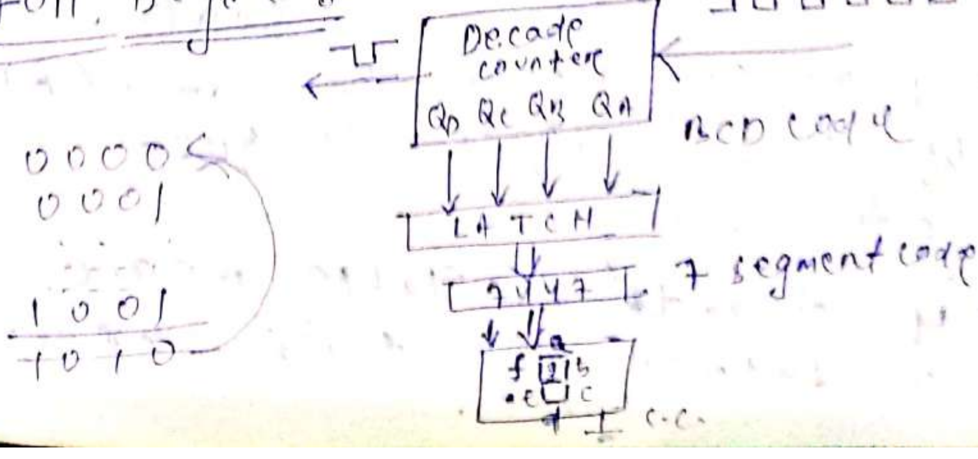
$$r = \frac{1}{10^N} \times \text{voltage Range}$$

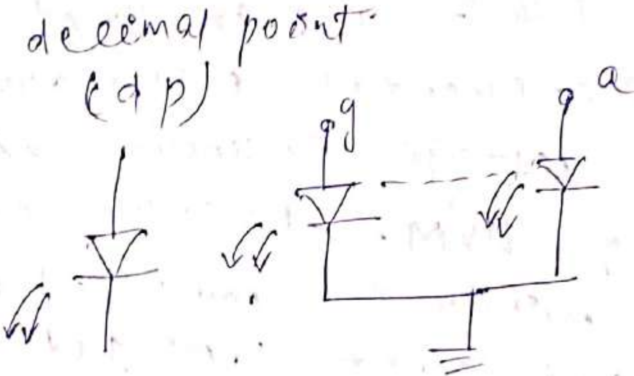
sensitivity of DVM :- The smallest voltage that can be measured in lowest voltage Range is known as sensitivity of DVM. i.e. minimum of minimum counts (10, 5, ③) is sensitivity.

$$\boxed{S = \frac{1}{10^N} \times R_L}$$

R_L = Lowest Range..

Full Digit :-





0 - off
1 - ON

g	f	e	d	c	b	a	COUNT
0	1	1	1	1	1	1	→  (Co)
0	0	0	0	1	1	0	→ 
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
1	1	0	1	1	1	1	

Reset = 0

minimum count = 1 ; maximum count = 9

Total counts = minimum count + max. count

= 1 + 9 = 10 counts

= 10 steps

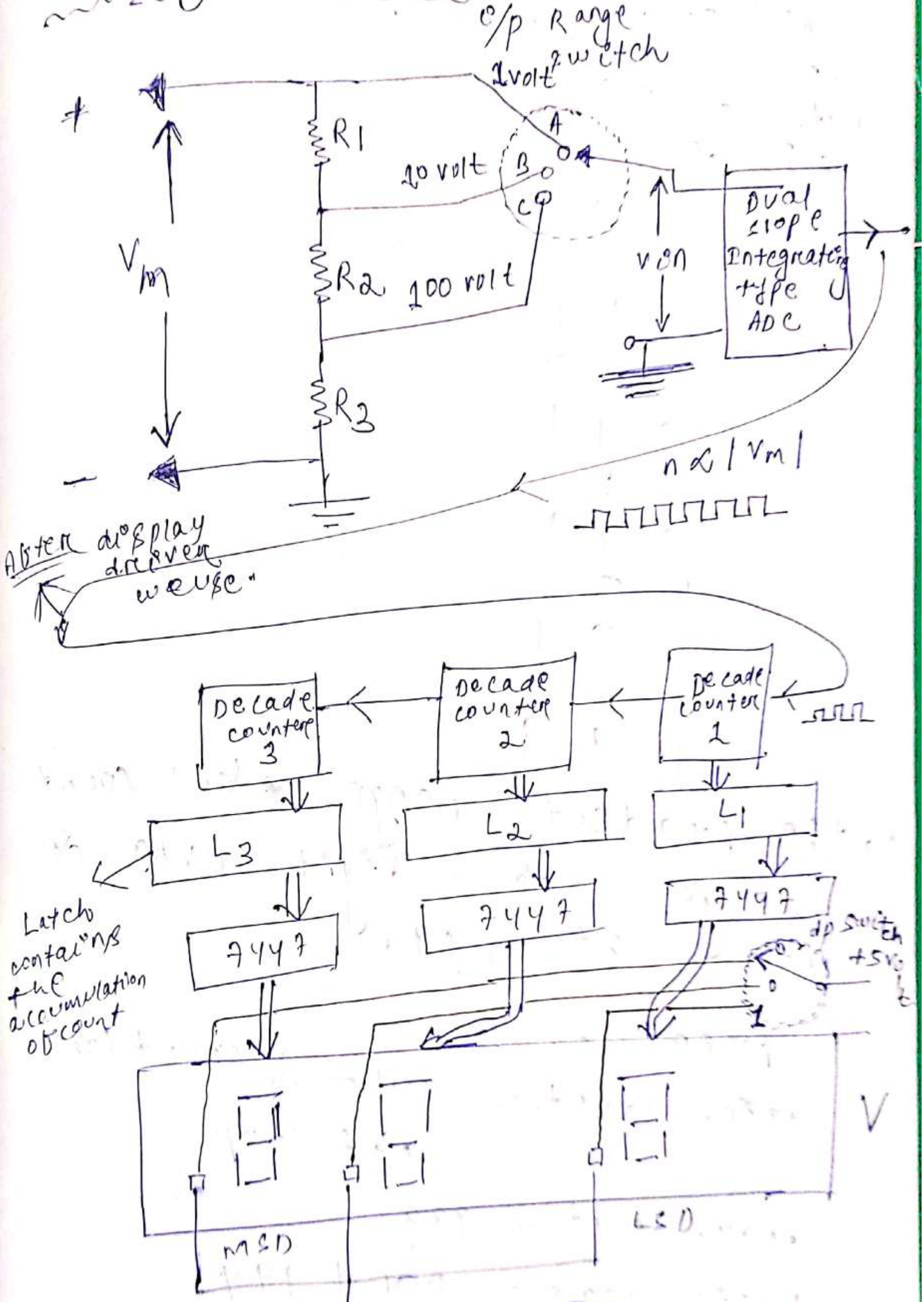
= Total steps.

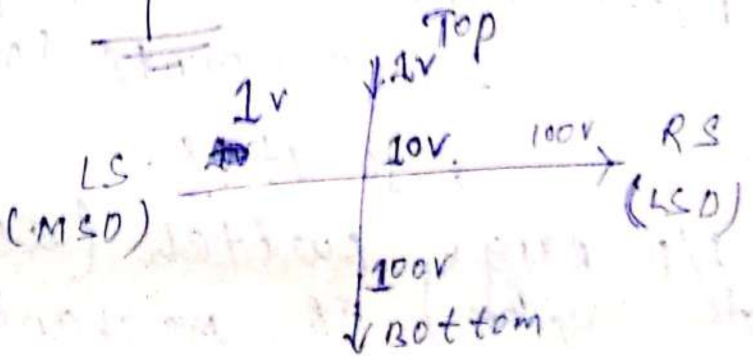
= scale.

→ Read out Range (or) count Range of a full digit is from 0 to 9.

↳ 4 digits available means 4 decade counters are available.

3 Digit DVM :-


c/p Range switch
1volt
+
−
A
B
C
10 volt
100 volt
R1
R2
R3
Vm
Vin
Dual slope Integrating type ADC
n ∝ |Vm|
After display driver we use.
Decade counter 3
Decade counter 2
Decade counter 1
L3
L2
L1
7447
7447
7447
Latch contains the accumulation of count
dp switch
+5v
0
1
V
MSD
LSD


Top
1v
1v
LS
(MSD)
10V.
100V
RS
(LSD)
100V
Bottom

Roll over of 3 digits

0 0 0

1st step → 0 0 1

0 0 2

⋮

0 0 9

0 1 0

0 1 1

⋮

0 9 9

1 0 0

1 0 1

⋮

9 9 9

↳ The Readout range (or) count range of 3 digit DVM is from 0 to 999.

↳ Reset = 000

Min. count = 001 - 1 count (or) 1st step

Max. count = 999

Basic scale = 001 + 999.

= 1000 counts (or) 1000 steps

= 10^3 steps.

↳ I/P Range switch (accessable to user) is mechanically ganged with o/p switch.

ganged

Range switch		o/p switch	
Ⓐ	$V_{en} = V_m$	Ⓐ	$\boxed{\cdot\qquad}$ V .001V → .999V $\xleftrightarrow{\text{1 V Range}}$
Ⓑ	$V_{en} = \frac{R_2+R_3}{\Sigma R} \cdot V_m$	Ⓑ	$\boxed{\quad\cdot\quad}$ V_m 0.01V → 9.99 V $\xleftrightarrow{\text{10 V RANGE}}$
Ⓒ	$V_{en} = \frac{R_3}{\Sigma R} \cdot V_m$	Ⓒ	$\boxed{\qquad\cdot}$ V 00.01 → 99.9 V $\xleftrightarrow{\text{100V RANGE}}$

1 V Range	10 V Range	100 V Range
. _ _ _ V 1mV	_ . _ _ V 10mV	_ _ . _ V 100mV
.0 0 1 V	0 . 0 1 V	0 0 . 1 V
.0 0 2 V	0 . 0 2 V	0 0 . 2 V
⋮	⋮	⋮
	0 . 9 9 V	0 0 . 9 V
	⋮	⋮
		0 9 . 9 V
		⋮
. 9 9 9 V	9 . 9 9 V	9 9 . 9 V

Resolution of 3 digit DVM $= \frac{1}{10^3}$

$= \frac{1}{1000 \text{ steps}}$

= 1 : 1000 steps

= '1' out of "1000" steps". = 0.001

Reading of 3 digit DVM in 1 volt Range $= \frac{1}{10^3} \times 1$ volt $= \frac{1 \text{ volt}}{1000 \text{ steps}}$

$= \boxed{1 \text{ mV}}$

.001 volt

⇒ 1 mV

↳ Resolution of 3 digit DVM in 10 volt Range = 0.01 V

⇒ 10 mV

$= \frac{1}{10^3} \times 10$ V

$= \frac{10 \text{ V}}{1000 \text{ steps}} = 10$ mV

↳ Reading of 3 digit DVM in 100 V Range $= \frac{1}{10^3} \times 100$ volt

0.01 V

⇒ ~~100~~ 100mV

$= \frac{100 \text{ volt}}{1000 \text{ steps}}$

$= \boxed{100 \text{ mV}}$

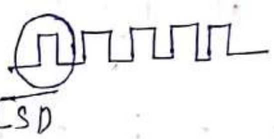
sensitivity of 3 digit DVM in a lowest range of operation of 1 volt is ——.

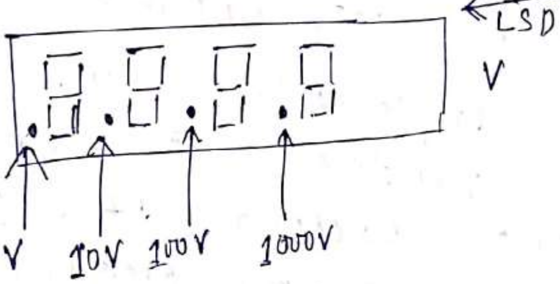
Soln. $S = r \times (R)_L$

$= \frac{1}{10^3} \times 1$ volt $= \boxed{1 \text{ mV}}$

	min. voltage (r)	max voltage
1 v range	.001 V	.999 V
10 V range	0.01 V	9.99 V
100 V range	00.1 V	99.9 V

4 digit DVM :





Roll over :

0 0 0 0

0 0 0 1 ← min (or) r

⋮

9 9 9 9 — MAX

↳ The count ~~[illegible]~~ range of a 4 digit DVM is from 0 to 9999 "

Basic scale = 0001 + 9999 = 10,000 steps
= 10^4 steps
= 10^4 counts

The 4 digit DISPLAY is driven from a Scale of 10^4 counter consisting 4 decade counters cascaded .

$\rightarrow r = \frac{1}{10^4} = 1 : 10,000 = 0.0001$
= Basic scale Resolution

$r = 0.0001$

↓ × 1 volt
$r_{1V} = 0.1 mV$

↓ × 10 V
$r_{10V} = 1 mV$

↓ × 100 V
$r_{100V} = 10 mV$

↓ × 1000 V
$r_{1000V} = 100 mV$

4 digits	Min. voltage	MAX. voltage
1 v range	.0001 V	.9999 volt
10V range	0.001 V	9.999 volt
100V range	00.01 Volt	99.99 volt
1000V range	000.1 volt	999.9 volt

Extension digits:- These digits are the count range of used for extending a N digit dB.

— x —

ERRORS in M.I. instrument :

ELECTRONIC MEASUREMENT

~~An extension~~
↳ Decimal point (D.P) does not exist, for extension digit. As such when an extension digit is attached (At most significant position MSD), new voltage Range is not added. But, the existing voltage ranges are extended.

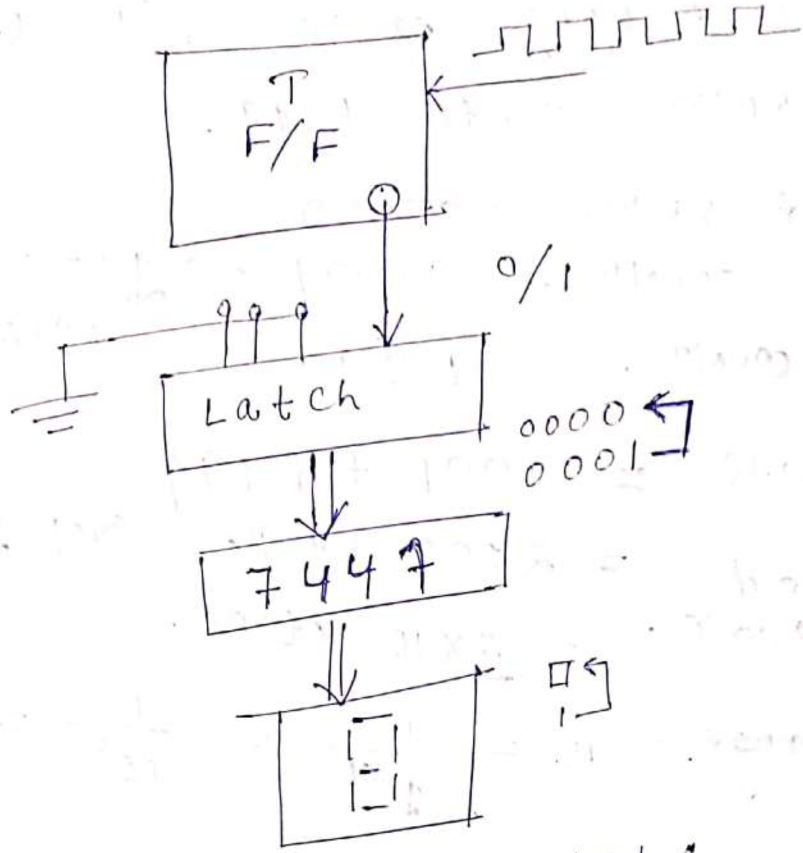
Spec: $\frac{X}{Y}$ digit

where X = MAX. count
Y = Total counts
(* Y is the range multiplying factor.)

* By attaching an extension digit, minimum count, Resolution, sensitivity, minimum voltage (or) unaltered. where as count range, maximum count, maximum voltage are unaltered.

	count Range	MAX. count	Total count
$\frac{1}{2}$ digit (T-FF)	0, 1	1	2
$\frac{3}{4}$ digit	0, 1, 2, 3	3	4
$\frac{5}{6}$ digit	0, 1, 2, 3, 4, 5	5	6

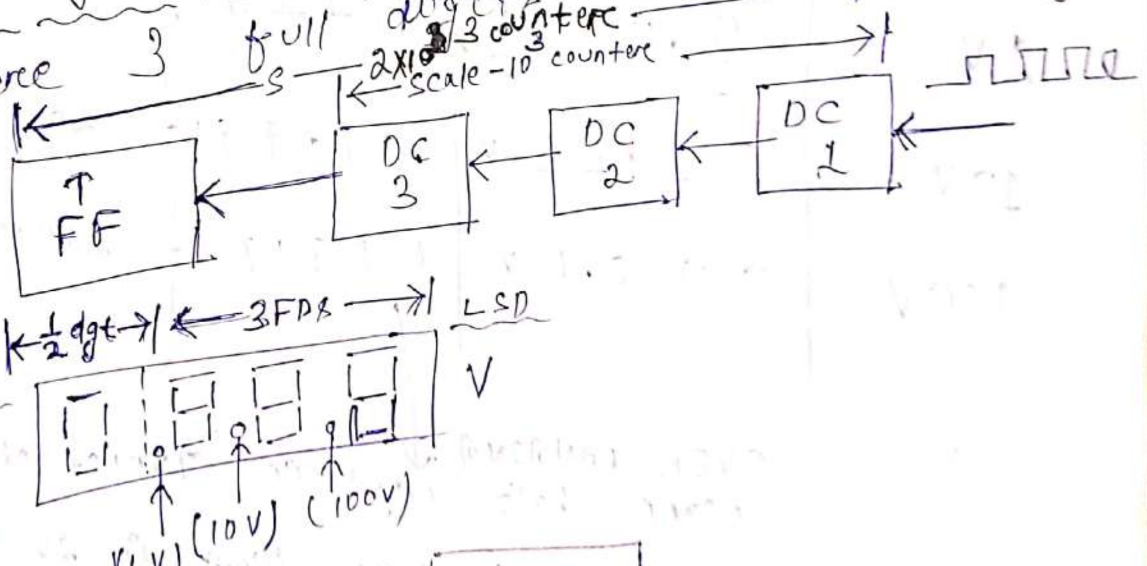
EX :-



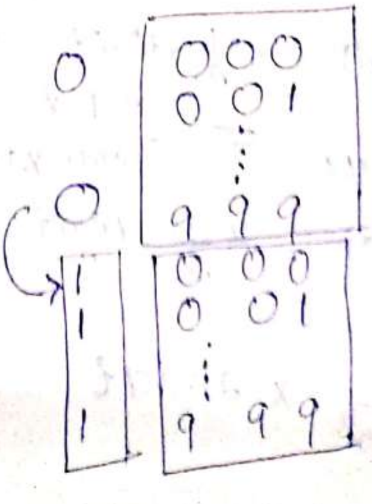
$\frac{1}{2}$ digit displays either 0 (or) 1.

Ⓧ 3 $\frac{1}{2}$ digit DVM :-

↳ There are 3 full digits and 1 half digits.



↳ Roll over :-



↳ The count Range of 3 ½ digit DVM, is from 0 to 1999.

→ Reset value – 0000

MIN COUNT – 0001 → 1 count (or) Resolution

MAX COUNT – 1999

→ scale = 0001 + 1999

= 2000 steps. (or) 2000 counts.

* extended scale. = 2 × 10^3 steps.

↳ ~~range~~ $r = \frac{1}{10^4} = \frac{1}{10^3} = \boxed{0.001}$

Basic voltage range	Min voltage sensetivity.	MAX. voltage	Extended voltage Range
1 V	0.001 V	1.999 V	2 V
10 V	00.01 V	19.99 V	20 V
100 V	00 0.1 V	199.9 V	200 V

OVER RANGING ↓ means half digit is Turned ON.

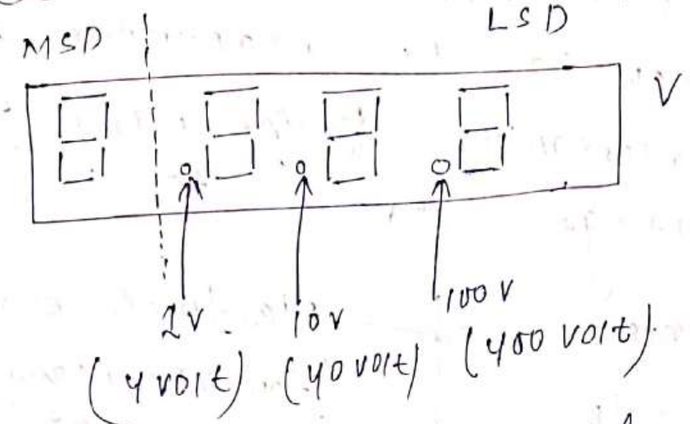
↳ Resolution of 3 ½ digit DVM in 2V range is ____.

$= \frac{2\,V}{2000\text{ steps}} = \frac{1\,V}{1000\text{ steps}} = \boxed{1\text{ mV}}$.

↳ Resolution of 3 ½ digit DVM in 20V range is ____.

$= \frac{1}{2 \times 10^3} \times 20\text{ volt} = \frac{1}{10^3} \times 10\text{ volt} = \boxed{10\text{mV}}$

(X) $3\frac{3}{4}$ digit DVM :-



→ 0 000 – reset

0 001 – min

⋮

3 999 – MAX

→ The count range of $3\frac{3}{4}$ digit ~~of~~ DVM is from 0 to 3999.

→ Extended scale = 0001 + 3999
= 4000 = 4×10^3 steps

$r = \frac{1}{10^3} = 0.001$

→ Resolution (r) in 1V range = $\frac{1}{10^3} \times 1$ V = 1 mV

(or)

r in 4V range = $\frac{1}{4 \times 10^3} \times 4$ volt = 1mV

0.001 volt ⇒ 1 mV

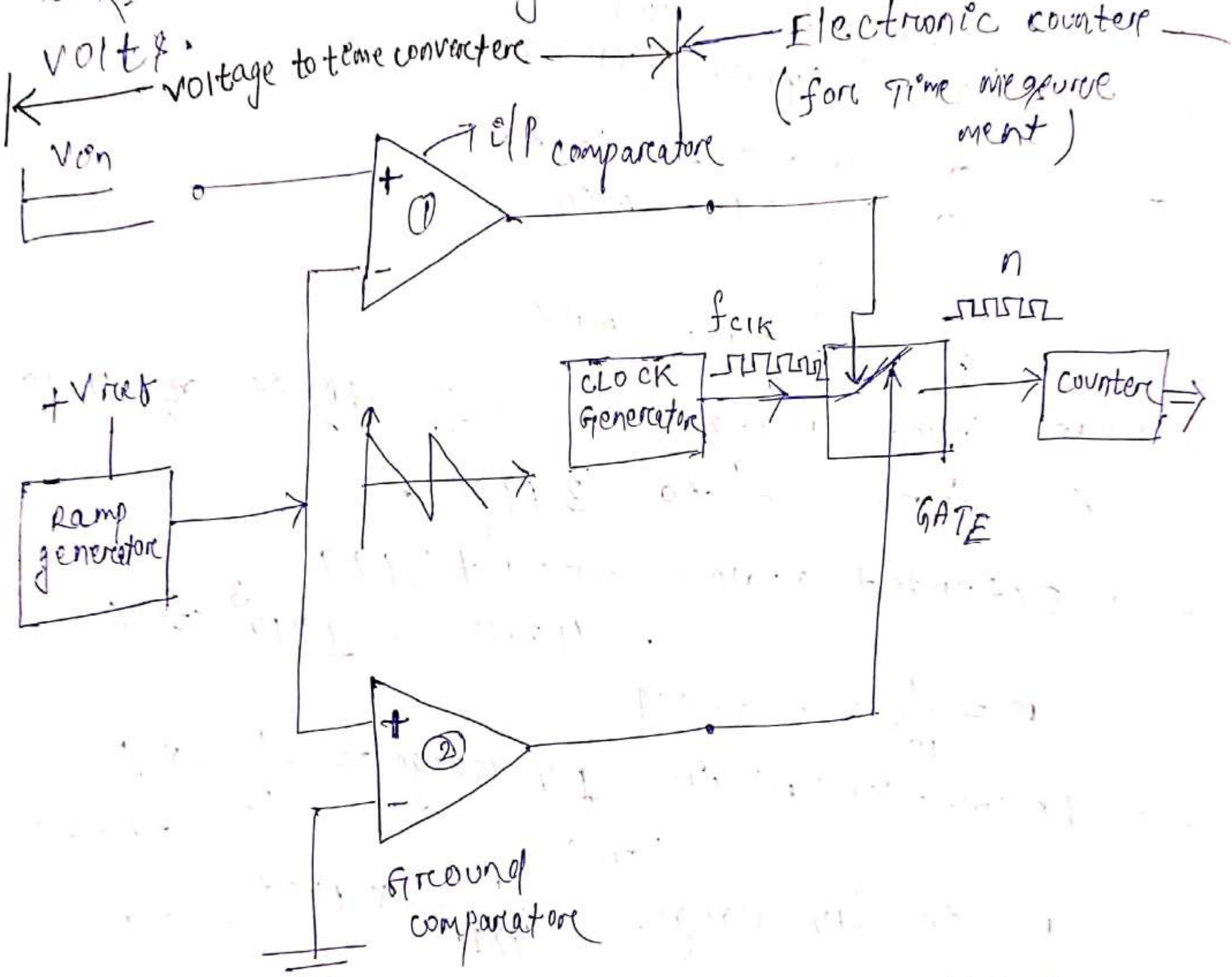
→ 1V :⇒ 0.001 volt to 3.999 volt ⇒ 4 volt

10V :⇒ 00.01 volt to 39.99 volt ⇒ 40 volt

100V :⇒ 000.1 volt to 399.9 volt ⇒ 400 volt

⊗ RAMP TYPE DVM :-

principle of operation :- The unknown analog DC voltage is measured by measuring the time taken by a linearly falling ramp from unknown voltage level to zero volts.



where, $V_{ref.}$ = Reference voltage.

V_m = unknown analog dc voltage.

t_r = Time taken by Ramp to fall from V_{ref} to 0volt.

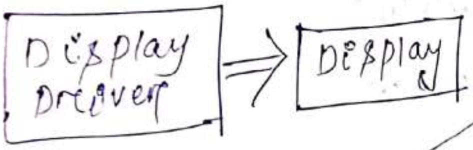
t_m = Time taken by ramp to fall from V_m to 0 volt.

(∗ $t_m = t_2 - t_1$)

1C = 1st coincidence (or)
1st cross over.

2C = 2nd coincidence (or)
2nd crossover.

Display ~~with~~ modulate with driver.

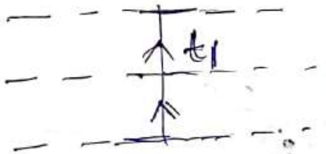


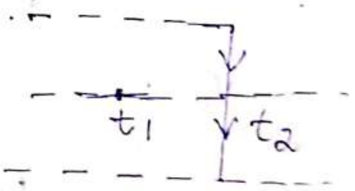
Voltage To Time conversion :-

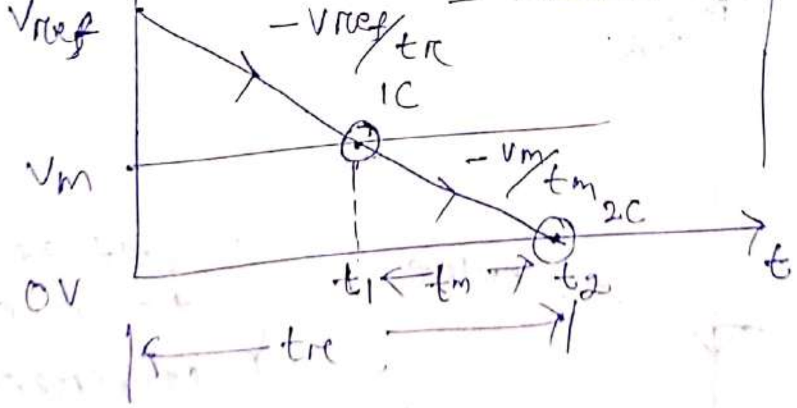
→ Input comparator compares $\underset{(-)}{V_{ramp}}$ with $\underset{(+)}{V_m}$.

→ Z.C.D. compares $\underset{(+)}{V_{ramp}}$ with $\underset{(-)}{0}$.

o/p of input comparator	o/p of zero crossing detector (or) ground comparator
0 to t_1 :- $V_{ramp} > V_m \Rightarrow$ (-ve)	up to t_2: $V_{ramp} > 0 \Rightarrow$ +ve
at t_1 :- $V_{ramp} = V_m = 0$	at t_2: $V_{ramp} = 0 \Rightarrow 0$
$> t_1$: $V_{ramp} < V_m \Rightarrow$ +ve	$> t_2$: $V_{ramp} < 0 \Rightarrow$ -ve







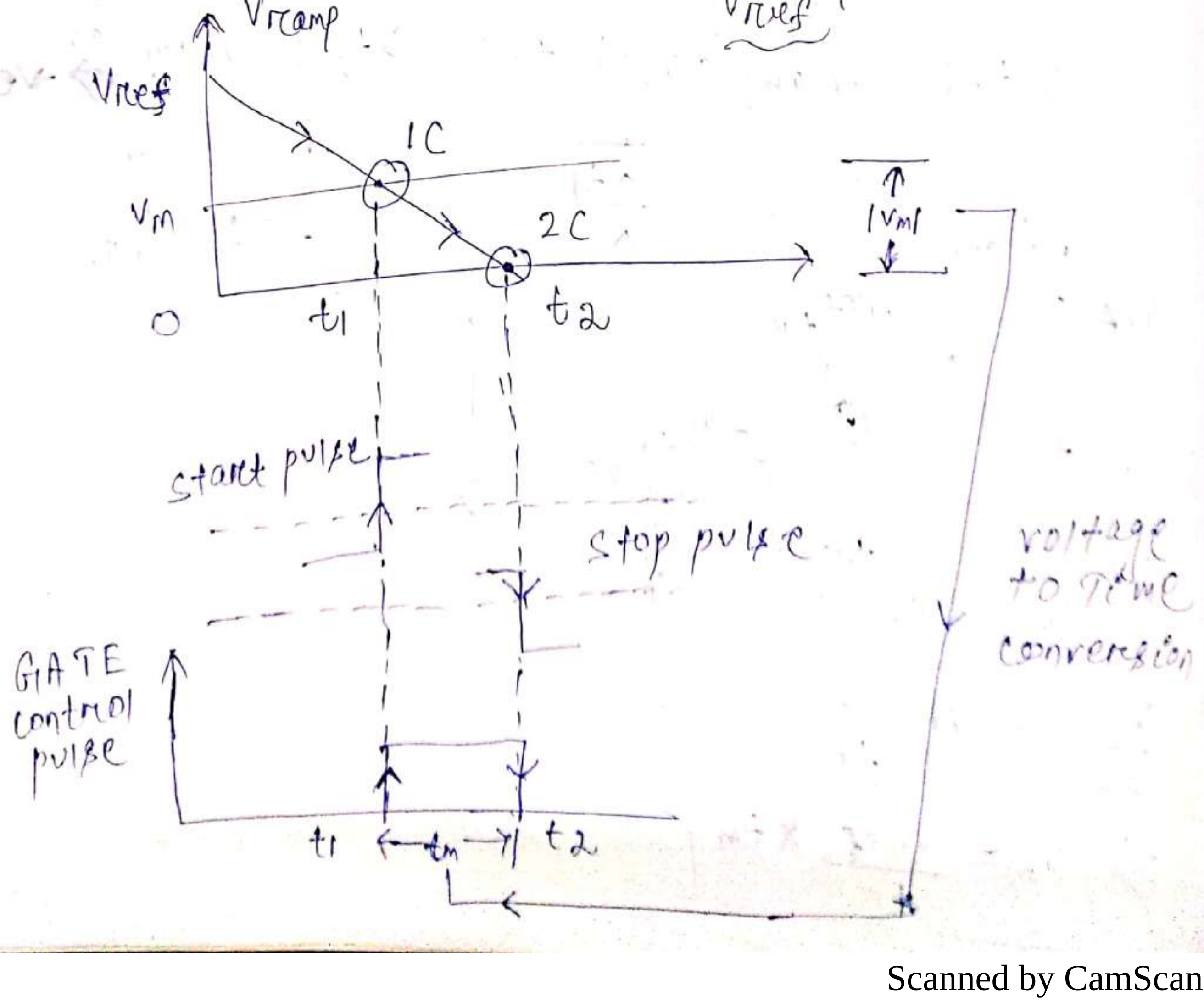
$$\frac{V_m}{t_m} = V_{ref}/t_r$$

$$\Rightarrow \boxed{V_m = \frac{V_{ref}}{t_r} \times t_m}$$

→ At t_1 the Ramp ~~the~~ voltage coincides with V_{in}. This is known as 1st coincidence, it will be detected by i/p comparator that generates a start pulse.

→ At t_2 the ramp voltage (Vramp) coincides with zero volt. This is known as 2nd coincidence, it will be detected by ground comparator. As such the gnd comparator generates falling / stop pulse at t_2.

→ t_m is time taken to give V_m i.e. Vref.



(*) → $t_{re} \to V_{ref}$

$t_m \to V_m$

$$\boxed{\therefore V_m = \frac{V_{ref}}{t_{re}} \times t_m} \quad (1)$$

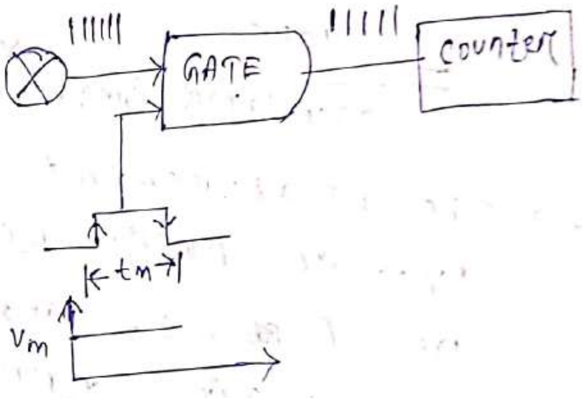
slope

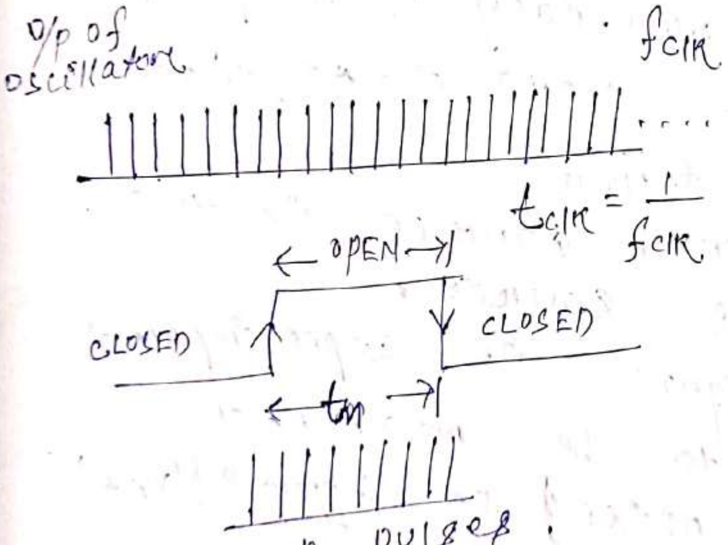
control pulse width.

It is electronic counter, (or) frequency counter.

Time measurement using Electronic counter :-

The GATE timer is Tm i.e. gate is open for a duration of Tm. n no. of clk pulses are counted in that duration.





* GATE switch is OPEN means, GATE is closed.

" " " CLOSED " " " OPEN.

* 'n' clk pulses are counted in a duration of tm.

$$\boxed{\therefore t_m = n \times t_{clk}}$$

Accumulated count

clk pulse duration.

putting in eqn-①,

$$V_m = \frac{V_{ref}}{t_r} \times t_m$$

$$= \frac{V_{ref}}{t_r} \times n \times t_{clk}$$

$$\Rightarrow \boxed{V_m = \left[\frac{V_{ref}}{t_r} \times t_{clk}\right] \times n}$$

unknown analog dc voltage to be measured = slope × clock pulse width × Accumulated count.

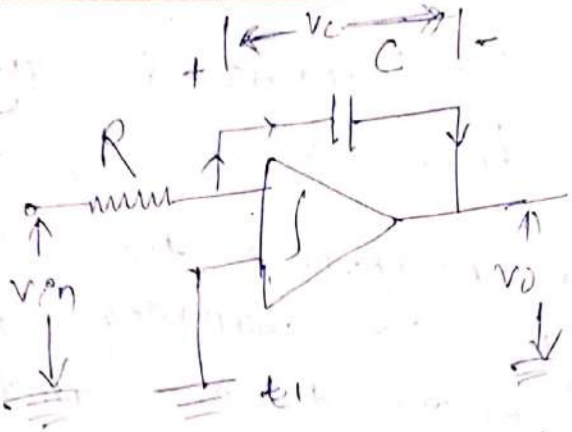
= $\frac{\text{slope}}{\text{oscillator freq.}}$ × Accumulated count.

→ The measurement accuracy of Ramp type DVM is poor. BCZ there is a dependency on R, C, and t clock.

↳ The main error source is the linearity of the source.

↳ If any AC signal is superimposed on DC voltage to be measured (power line noise) (or) ~~term~~ HUM effect) then a large error are introduced in to measurement. As such noise rejection of this DVM is poor. In term the stability of this DVM is also poor since this is not stable when used in noisy condition (or) noise environment.

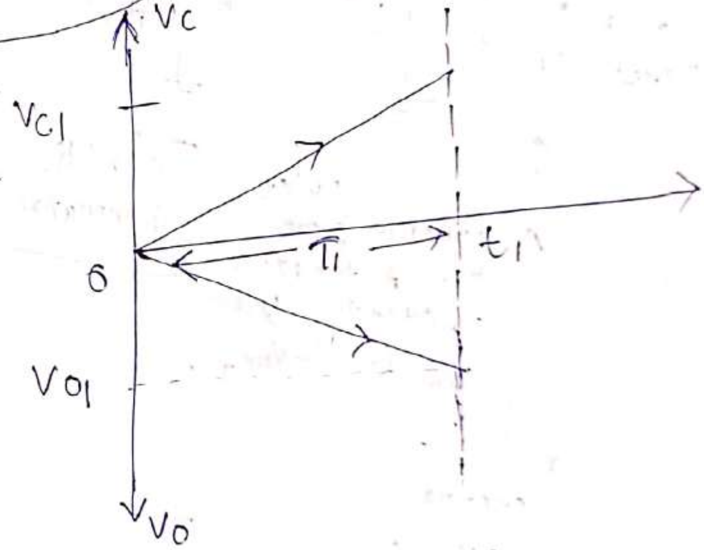
Integrator :-



$$\boxed{V_0 = -V_c} \quad , \quad V_c = \frac{1}{c}\int_{-\infty}^{t_1} I\,dt = \frac{1}{C}\int_{-\infty}^{t_1} \frac{V_{in}}{R}\cdot dt$$

$$= \frac{1}{RC}\int_{-\infty}^{t_1} V_{in}\cdot dt$$

$$\boxed{\therefore \; V_0 = -\frac{1}{RC}\int_{-\infty}^{t_1} V_{in}\cdot dt}$$



T_1 = Integration time period

= 0 to t_1.

$$V_{c1} = \frac{V_{in}}{RC}\left[t_1 - 0\right]$$

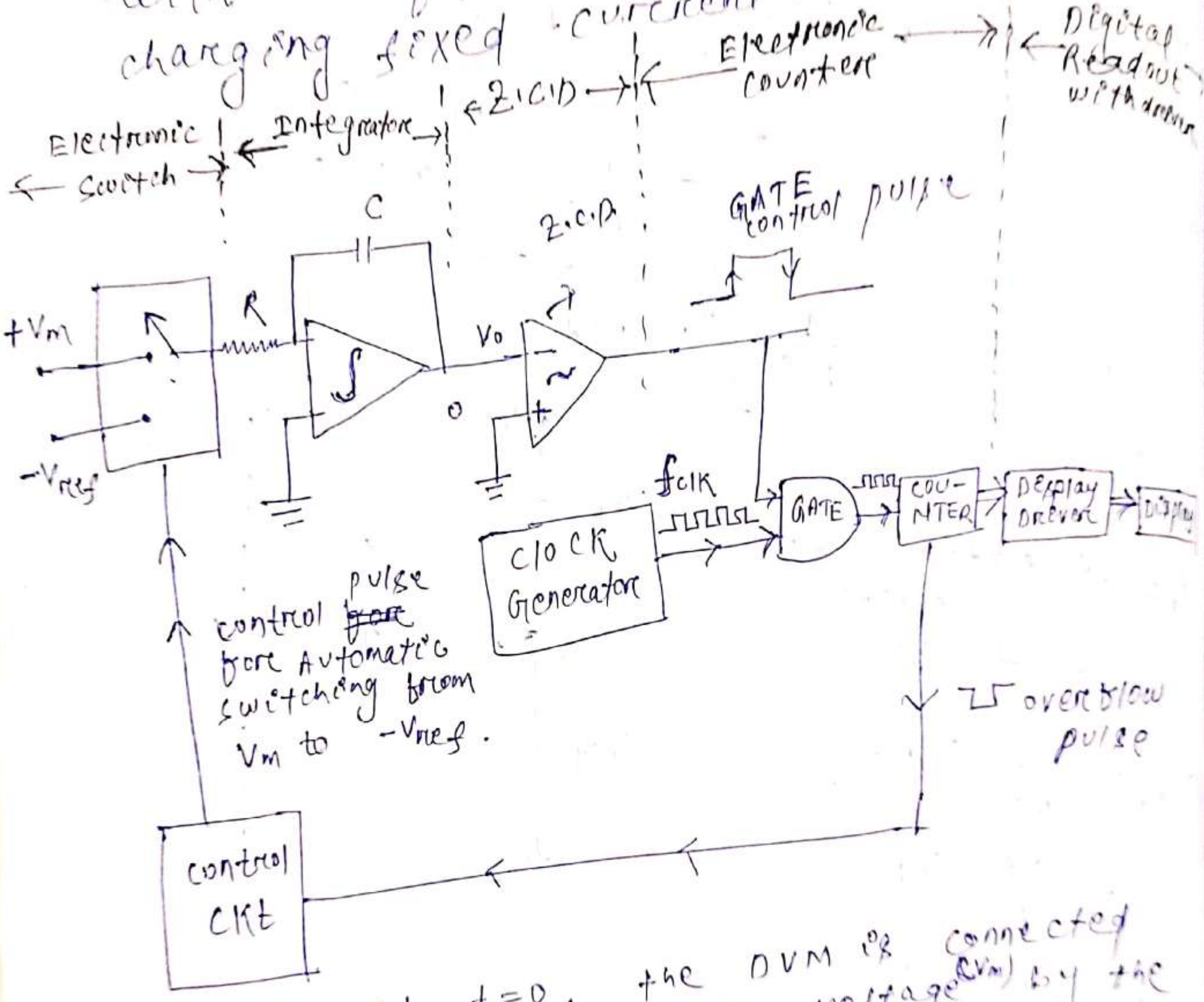
$$= \frac{V_{in}}{RC} T_1$$

$$\therefore V_{01} = -\frac{V_{in}}{RC} T_1$$

DUAL SLOPE INTEGRATING TYPE DVM :-

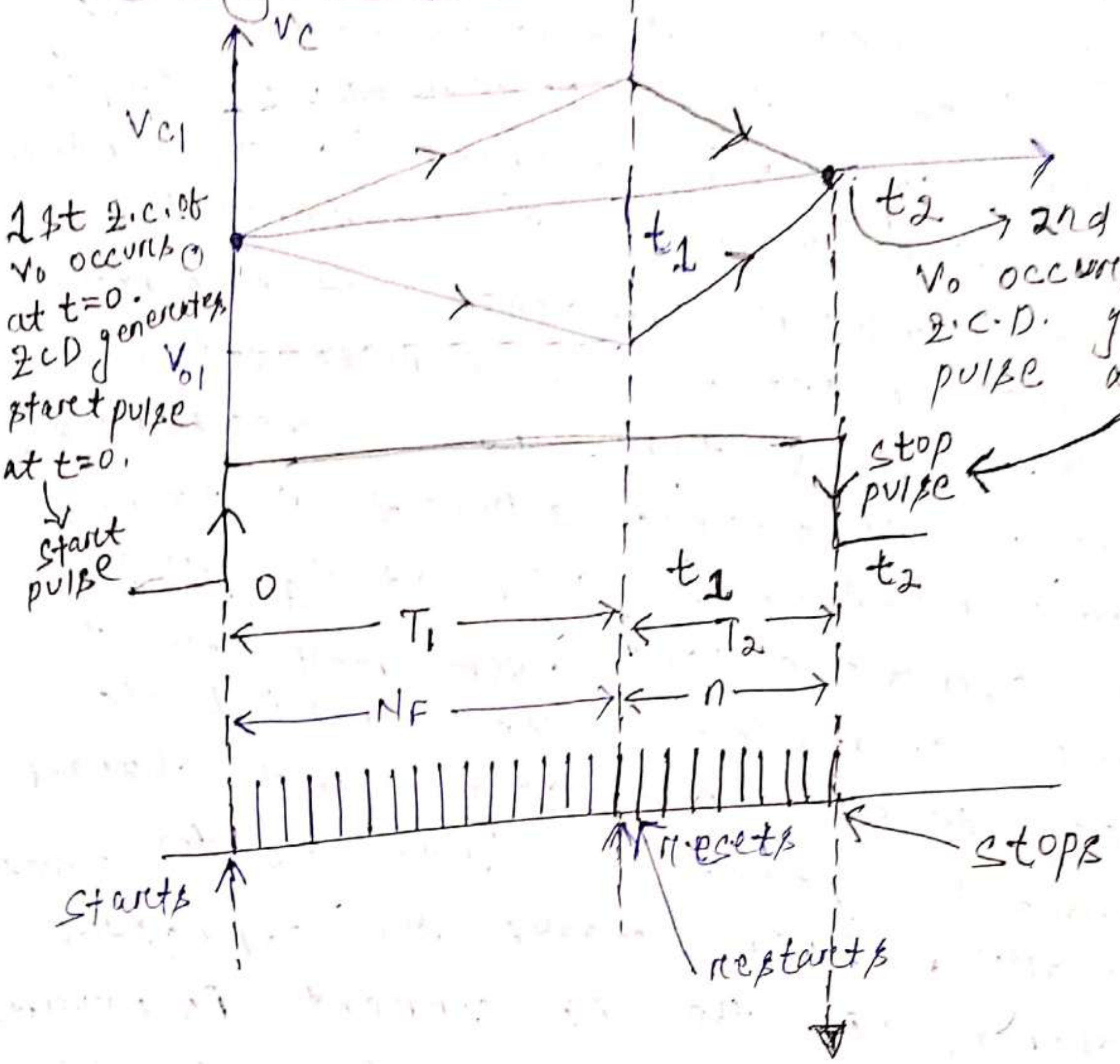
↳ It is the principle of voltage to time converter.

↳ This DVM measures the unknown analog dc voltage by charging a capacitor(C) with a fixed time and then dis-charging fixed current.



operation:- At t=0, the DVM is connected to the unknown analog DC voltage (Vm) by the user manually by throwing the switch in off direction. The capacitor starts charging and voltage across capacitor (+vely) rises, enterm the o/p of the integrator (-vely) rises. since there is 1st zero crossing of V₀ occures at t=0 it self. the Z.C.D. generates start pulse. This pulse opens the gate and in-form the clk pulses produced by oscillator ~~and~~ are allow to reach to the counter. counting starts from $t=0$ onwards. As ~~capac~~ integrating capacitor charges (with variable current) the counting is continued till the counter reaches it's maximum count and reset. i.e. irrespective of magnitude of voltage being measured, the counter is always allowed to counted up to it's maximum. say, at t_1, the counter overflows (or) ~~over roll~~ that generates overflow pulse which is feedback to the i/p side and changes the switch position from V_m to $-V_{ref}$, automatically. This makes the capacitor to discharge as the i/p current is reversed but have no effect on ~~gat~~ GATE. As the gate is still open the counter restarts from t_1 onwards. This counting is continued till capacitor discharges completely. say at t_2 capacitor is completely discharged and the o/p of integrator becomes 0. This 2nd zero crossing of V_o (occuring at t_2) generates ~~a~~ the Z.C.D. to generate stop ~~free~~ pulse that closes the GATE. so counting ~~starts~~ stops at t_2.

Timing Diagram :-



Relation between 'n' and V_m :-

w.r.t. 't'	o/p of integration
$t=0$	$V_{00} = 0$ --- (→ 1st ZC)
$0 < t < T_1$ $\leftarrow T_1 \rightarrow$	$V_0 = \frac{-1}{RC} \int_{-\infty}^{t_1} v_m \cdot dt$ $V_0 = \frac{-1}{RC} \int_{0}^{t_1} V_m \cdot dt$ [∵ no initial voltage]
At $t=t_1$	$V_{01} = -\frac{V_m}{RC} [t]_0^{t_1}$ $= \frac{-V_m}{RC} [t_1 - 0]$ $\boxed{V_{01} = -\frac{V_m}{R \cdot C} T_1}$ —— ①

$t_1 < t < t_2$

$$V_0 = \frac{-1}{RC}\int_{-\infty}^{t_2}(-V_{ref})\cdot dt$$

$$= \frac{V_{ref}}{R\cdot C}\int_{0}^{t_2} dt$$

$$= V_{01} + \frac{1}{RC}\int_{t_1}^{t_2} V_{ref}\cdot dt$$

At $t = t_2$

$V_{00} = 0$ ----(-- 2nd z.c.)

$$V_{01} + \frac{V_{ref}}{RC}(t_2 - t_1) = 0$$

$$\frac{-V_m}{RC}T_1 + \frac{V_{ref}}{RC}T_2 = 0$$

$$\frac{V_m}{RC}T_1 = \frac{V_{ref}}{RC}T_2$$

$$\Rightarrow \boxed{\frac{V_{ref}}{T_1} = \frac{V_m}{T_2}}$$

$$\Rightarrow \boxed{V_m = V_{ref}\cdot\frac{T_2}{T_1}}$$

$$\Rightarrow V_m = V_{ref} \times \frac{n \times t_{clk}}{N_F \times t_{clk}}$$

$$= V_{ref} \times \frac{n}{N_F}$$

$$\Rightarrow \boxed{V_m = \left(\underbrace{\frac{V_{ref}}{N_F}}_{x}\right) \times n}$$

$$I_\omega = \frac{3.2}{200+200+2800} = 1\,mA$$

$$1\,mA \times 200\Omega = \boxed{0.2\ volt}$$

Here, $E_x = 0.2$ volt then there is no current will flow in galvanometer.

——x——

Electronic Em measurement :-

where T_1 = 1st integration Time period. (fixed)

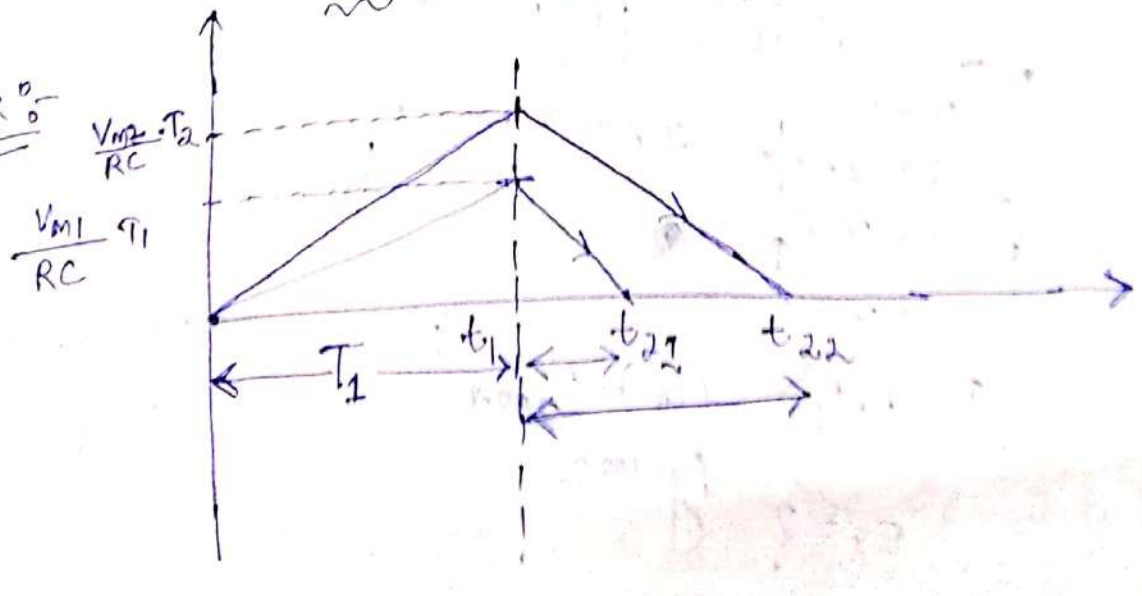
T_2 = 2nd " " (variable)

(or) De-integration Time period.

* During T_1 :- V_m is integrated, capacitor charges with variable current upto MAX $\frac{V_m}{R}$. counter count ~~current~~ count slope is variable.

* During T_2 :- V_{ref} is integrated capacitor discharges with fixed current up to $\frac{V_{ref}}{R}$ counter counts n, slope is fixed.

Ex :-



Conversion Time :-

t_{conv} = start to stop pulse

= 0 to t_2

= 0 to t_1 + t_1 to t_2

$$\boxed{t_{conv.} = T_1 + T_2}$$

$= N_F \cdot t_{clk} + n \cdot t_{clk}$

$$\boxed{t_{conv.} = (N_F + n) \cdot t_{clk}}$$

Note:- Maximum conversion time when $n = N_F$.

Note:- $N_F = 10^N$ ...... N digit DVM

$= 2^n$ ...... n bit A/D converter.

Note:- (In 1st ~~ent~~ time period, the counter counts up to $10^N - 1$ .... DVM (or) $2^n - 1$ .... ADC.)

The measurement accuracy of the dual slope type is high. since there is no dependency on R, C, tclock.

Measured value :-

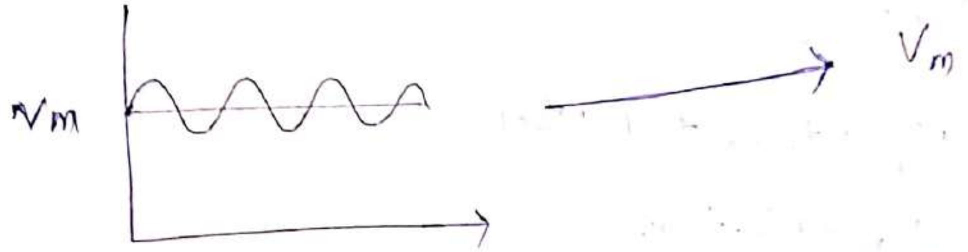
$$|V_o| = \frac{1}{RC} \int_0^{t_1} V_m \cdot dt \quad \text{If } T_1 = RC$$

then, $|V_o| = \frac{1}{T_1} \int_0^{t_1} V_m \cdot dt$ ⟶ True avg. value of V_m.

∴ Dual slope integrating type DVM measures true average value of V_m.

* input

measured value is Avg. value



↳ Any AC signal (or) noise as present on the dc voltage to be measured will be rejected since the ~~with~~ dual slope type design integrates the analog voltage to be measured for a fixed time period.

Design issue:- $\boxed{T_1 = n T_s}$ ← condition to supress line noise.

where T_1 = 1st integration time period.

T_s = Time period of sinusoidal component riding on DC voltage to be measured.

$T_1 = 1 \times T_s$ — minimum integration time period.

$2 \times T_s$

⋮

$10 \times T_s$

* stability :- integrating type DVM offers highest Dual slope integrating, it has highest noise. reject stability since.

conclusion:- Dual slope integrating type DVM is the most widely used DVM because of its heighest accuracy, highest

noise rejection, highest stability
(But it is the slowest DVM.)

Que:- A digital voltmeter has a $4\frac{1}{2}$ digit display. The 1 volt range can read up to —.

Soln:- 1 . 9 9 9 9 volts

↑
1 V
(2V)

— x —

Que:- what is the reading of 0.5245 volt on 1volt range in $4\frac{1}{2}$ digit voltmeter displayed as — . ⓘ In 100volt range as — ?

Soln:- $V_m = 0.5245$ volt by $4\frac{1}{2}$ DVM

1V range : 0 . 5 2 4 5 volt

↑ 1volt

100V range : 0 0 0 . 5 2 V

— x —

Que:- Assertion:- The Resolution of $3\frac{1}{2}$ DVM is 0.001.

Reason:- Addition of $\frac{1}{2}$ digit to a digital voltmeter increases the range of the ~~of~~ meter.

Assertion: True
Reason: True.
But 'R' is not correct explanation of Assertion.

Que:- what is the range for a $3\frac{1}{2}$ digital meter ?

Sol^n: 0 to 1 9 9 9 ;

—x—

Que: A 4 digit DVM with a 100 mV lowest full scale range would have a sensitivity of how much value? , while the resolution of this DVM is 0.0001

(a) 0.1 mV
[✓ (b) 0.01 mV]
(c) 1.0 mV
(d) 10 mV

Sol^n: 4 digit DVM; $R_L = 100 \text{ mV}$

$$R = 0.0001$$

$$S = R \times (R_L) = 0.0001 \times 100 \text{ mV}$$

$$= \frac{1}{10^4} \times 100 \text{ mV} = \boxed{0.01 \text{ mV}}$$

—x—

Que: A $3\frac{1}{2}$ digit voltmeter having a resolution of 100 mV can be used to measure a ~~meas~~ maximum voltage of ____.

(a) 100 V
[✓ (b) 200 V]
(c) 1000 V
(d) 5000 V

Sol^n: $3\frac{1}{2}$ DVM, $R = 100 \text{ mV}$

$$\boxed{R = \frac{1}{\text{extended scale}} \times \text{extended voltage Range}}$$

$$100 \text{ mV} = \frac{1}{2 \times 10^3} \times \text{extended voltage Range}$$

∴ extended voltage Range $= 2 \times 10^3 \times 100 \text{ mV}$

$= 200$ volt

—x—

Que: What is the resolution of $2\frac{1}{2}$ digit display DVM for 0 to 1 volt range. What is the resolution on the 0 to 10 volt range.

Sol^n:- Given that : $3\frac{1}{2}$ digit DVM

Ranges : 0–1 volt , 0–10 volt

→ we know, $r = \frac{1}{\text{scale}} \times \text{Range}$

→ 0–1 volt Range:

$$r = \frac{1}{2\times10^3} \times 2V = \frac{2\text{ volt}}{2000\text{ counts}} = \frac{1\text{ volt}}{1000\text{ counts}} = \boxed{1\,mV}$$

0–10 volt Range:-

$$r = \frac{1}{2\times10^3} \times 20V$$

$$= \frac{20\,V}{2000\text{ counts}} = \frac{10\,V}{1000\text{ counts}}$$

$$= 10\,mV$$

Que:- A DVM has a readout range from 0 to 9999 counts. The Resolution of this instrument for the full scale reading of 9.999 volt.

Sol^n:- count range: 0 to 9999

⇒ 4 digits

FSV : 9.999 V → 10 volt range

∴ r of 4 digit DVM on 10V range

$$= \frac{1}{10^4} \times 10V = \frac{1}{10^3}\text{ volt} = \boxed{1\,mV}$$

(or: 0.001 V) → 1mV

9.999 V)

Que: A voltage 14·52 volt will displayed as —, by a $3\frac{1}{2}$ digit DVM in 100 volt range of opern?

ⓐ can not be measured

ⓑ

soln: 0 1 4 · 5 volt

— x —

Que:- A $4\frac{1}{2}$ digit DVM has the error as 0·2% reading specification [illegible] plus 10 counts. If a DC voltage of 100V is read on its 200V full scale. The max error that can expected is —.

soln: Accuracy specification: 0·2% of reading + 10 counts.

→ ~~$4\frac{1}{2}$ digit DVM~~

100volt reading by $4\frac{1}{2}$ digit DVM in 200volt range } → 1 0 0 . 0 0 V

↑ 200V range

→ 1 count = 0 0 0 .0 1 V (in 100 volt range)

∴ 10 counts = 10 × 000·01 Volt

= 10 × 0·01 V

$= \boxed{0{\cdot}1 \text{ volt}}$

$$\therefore \text{error} = \frac{0{\cdot}2}{100} \times 100\text{volt} + 0{\cdot}1\,V$$

= 0·2 volt + 0·1 volt

= 0·3 volt

↳ % Error in reading of 100volt $= \frac{0.3 \text{ volt}}{100 \text{ volt}} \times 100\%$

$= 0.3\%$

[* Note : 000.00 V
000.01 V
000.02 V
⋮
$\boxed{000.10\text{V}} \Rightarrow 10$ counts

[* Note :

error $= \frac{0.2}{1000} \times \underline{1}\,\underline{0}\,\underline{0}.\underline{0}\,\underline{0}$ volt $+ 10 \times \underline{0}\,\underline{0}\,\underline{0}.\underline{0}\,\underline{1}$ volt

$= \frac{0.2}{100} \times 100$ volt $+ 10 \times 0.01$ V

$=$ ~~0.2~~ 0.2 volt + 0.1 volt

$=$ 0.3 volt

—— * ——

Que:- A $3\frac{1}{2}$ digit DVM has an accuracy of ±(0.5% of reading + 1 digit). The possible error in volts is ______ when the instrument is reading 5 volts on the 10 volt range.

sol^n:- $3\frac{1}{2}$ DVM

±(0.5% of reading + 1 digit) ⟸ 1 count

reading = 5 volt on 10volt Range.

sol^n:- error $= \pm\left[\frac{0.5}{100} \times \underline{0}\,\underline{5}.\underline{0}\,\underline{0}\text{V} + \underline{0}\,\underline{0}.\underline{0}\,\underline{1} \text{ volt}\right]$

↑ 10V range ↑ in 10 V Range

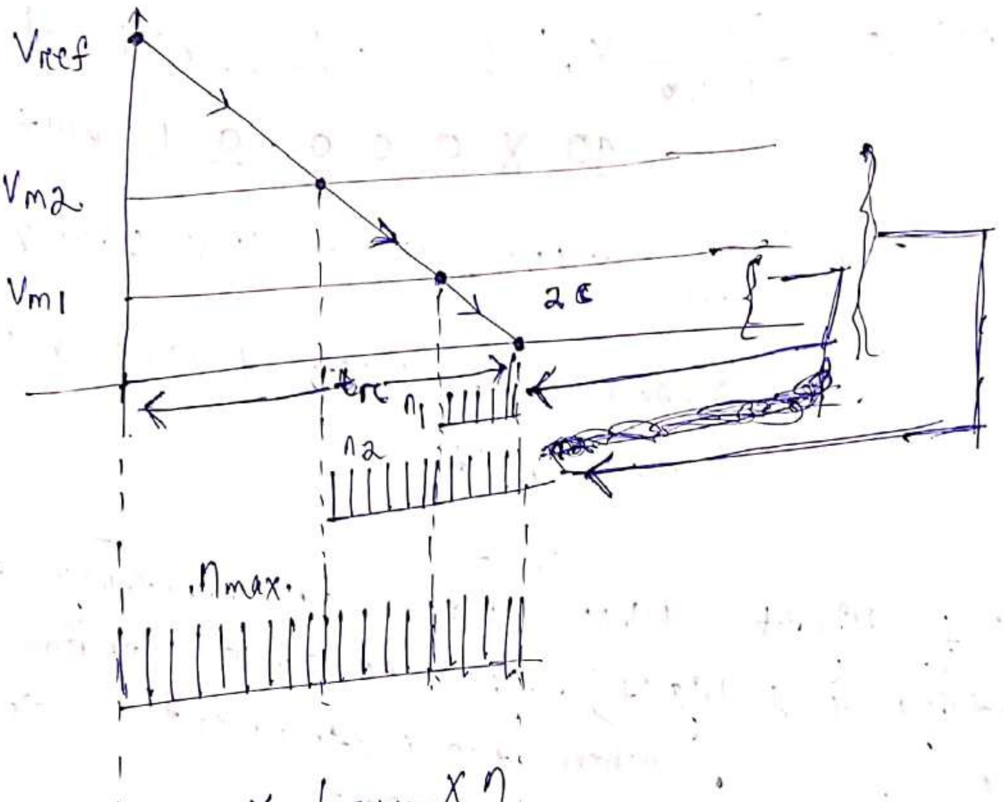
$= \pm\left[\frac{0.5}{100} \times 5\text{V} + 0.01\text{V}\right] = \pm\left[0.025\text{V} + 0.01\text{V}\right]$

$= \pm [0.035 \text{ volt}]$

——— x ———

Que:- In a digital voltmeter the oscillator frequency is 400 KHz. The Ramp voltage falls from 8 volt to 0 volts in 20 ms. The max. no. of pulses counted by the DVM is ——.

Sol:- Note:-



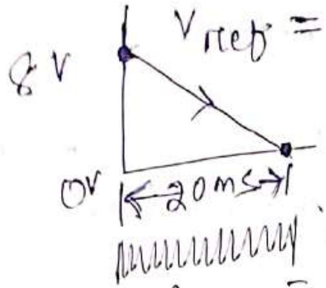
$V_m = V_{ref} \times t_{clk} \times n$

If $V_m = V_{ref} \Rightarrow t_m = t_r$

Then max. no. of pulses counted

$$\therefore V_{ref} = \frac{V_{ref}}{t_r} \times t_{clk} \times n_{max}$$

$$\Rightarrow \boxed{n_{max} = \frac{t_r}{t_{clk}}} = \boxed{t_r \times t_{clk}}$$



$20ms = n \times t_{clk}$

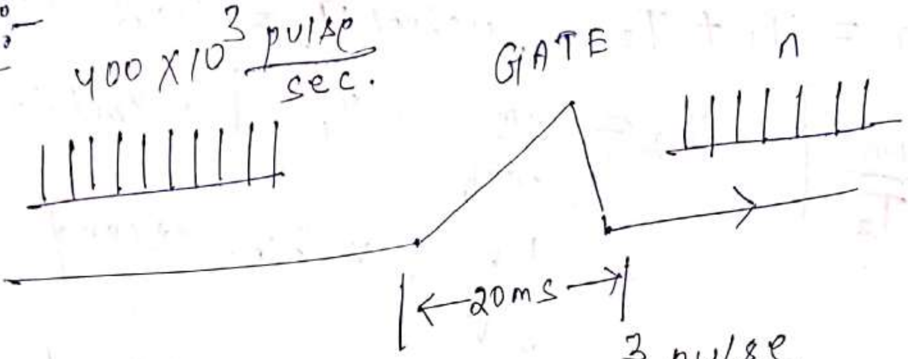
$t = n \times \frac{1}{f_{oscillator}}$

$n_{max} = 20\ ms \times 400KHZ$

$= 8000$ pulses

$\Rightarrow n = \text{timeperiod} \times f_{oscillator}$

Note:-



1 sec —— 400×10^3 pulse

20m sec → ?

$= \frac{20ms \times 400 \times 10^3 \text{ pulse}}{1\ ~~sec~~\ s}$

= 8000 pulses

Que:- The precision of ramp type DVM depends on ______ and slope of the Ramp.

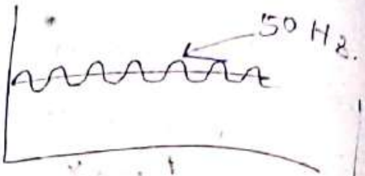
(a) freq. of generator
(b) " " "
(c) slope of the ramp.
(d) switching time of gate.

—— × ——

Que: In a Dual slope Integrating type DVM 1st integration is carried out for 10 periods of supply freq. 50HZ. The ~~Re.~~ V_{ref} = 2 volt. Then the total conversion time for a i/p voltage of 1 volt is ——.

Sol^n:- $T_1 = 10$ periods of $f_s = 50\,Hz$

$= 10 \times \frac{1}{50Hz}$

(∵ 

)

$= 10 \times 20\ ms$

$= 0.2$ second

$V_{ref} = 2$ volt and $V_m = 1$ volt

∴ $t_{conv} = T_1 + T_2$, where $T_1 = 0.2$ seconds.

$[∵ V_m T_1 = V_{ref} T_2]$

$$\boxed{\frac{V_{ref}}{T_1} = \frac{V_m}{T_2}}$$

$T_2 = \frac{V_m}{V_{ref}} \times T_1$

$= \frac{1\,V}{2\,V} \times 0.2$ second

$= \frac{1}{2} \times 0.2$ second

$= 0.1$ second

∵ $t_{conv} = 0.2\,s + 0.1\,s$

$= 0.3$ sec

—x—

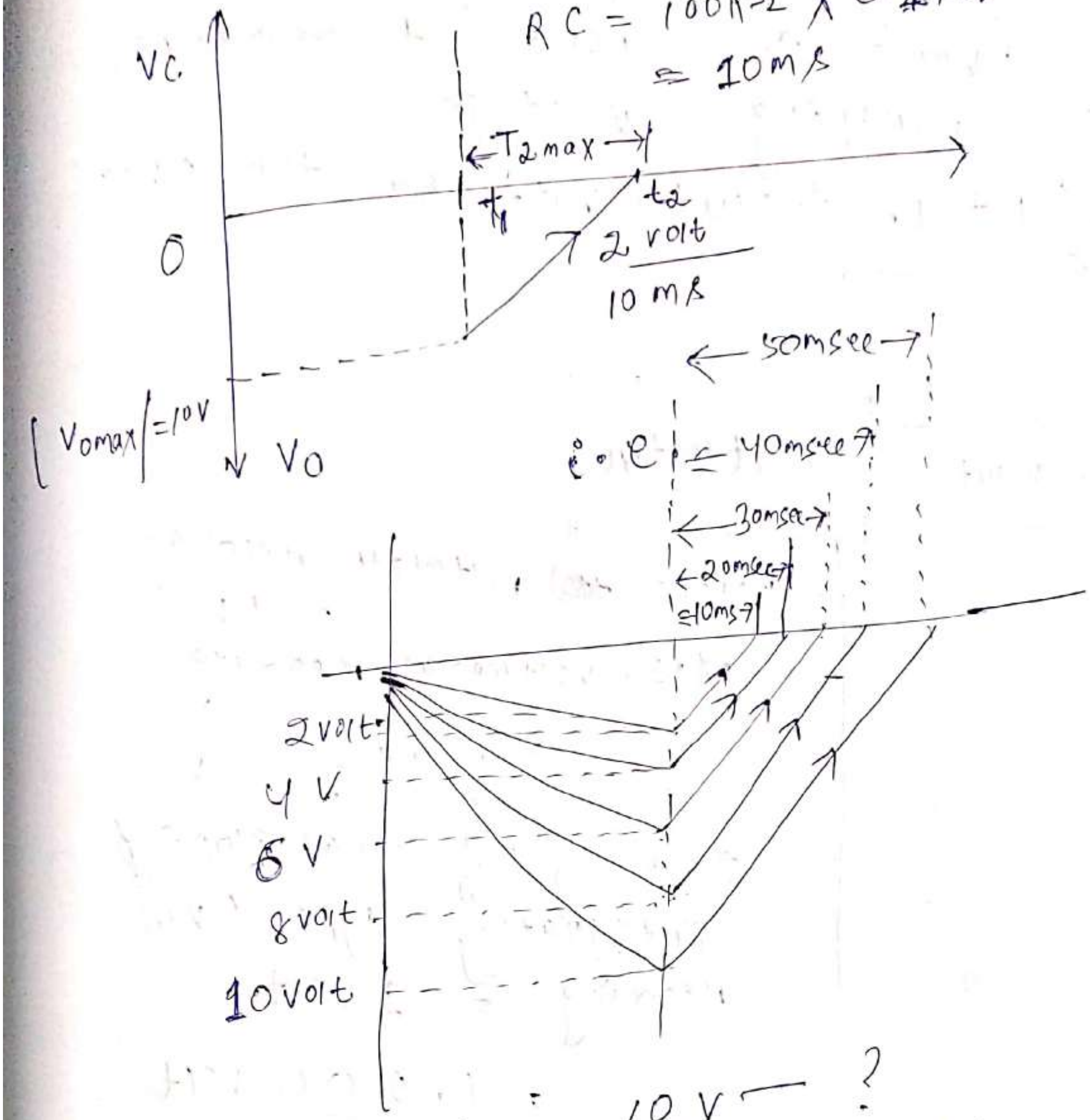
Que:- With a Block diagram explain the function of a dual slope integrating DVM. A dual slope integrating type DVM has an integrating capacitance of 0.1 μF and resistance of 100kΩ. The Vref = 2 volt. and the o/p of integrator ~~is~~ not to exceed 10 volt. Then calculate the maximum time for which Vref can be integrated.

Sol^n:- $V_{ref} = 2$ Volt,

$R = 100K\Omega$, $C = 0.1\,\mu F$

$|V_{omax}| = 10$ volt

$$RC = 100k\Omega \times 0.1\mu F = 10ms$$



2V — 10mS ; 10V — ?

$$\Rightarrow \frac{10V \times 10ms}{2V} = 50\ ms$$

$$|V_o| = \frac{V_m}{RC} \cdot T_1$$

where $T_2\max = T_1$ ↓ occurs if $V_m\max = V_{ref}$

$$\therefore |V_{o}\max| = \frac{V_{ref}}{R \cdot C} \times T_2\max$$

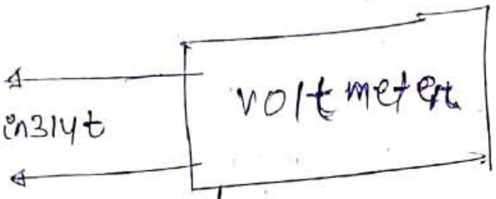
$$\Rightarrow T_2\max = \frac{|V_o\max|}{V_{ref}} \times RC$$

$$= \frac{|V_o\max|}{\left(V_{ref}/R\cdot C\right)} = \frac{10\ volt}{\left(\frac{2v}{10ms}\right)} = \boxed{50ms}$$

—x—

Que:- A $3\frac{1}{2}$ digit, 2 volt full scale dual slope DVM is used to measure a time varying voltage $v(t) = (1 + 1 \cdot \sin 314t)$ volt. Then the DVM indicate ______.

Solⁿ:-



$v(t) = 1+1 \cdot \sin 314t$

- PMMC voltmeter reading = 1 V
- M.I. voltmeter reading = $\sqrt{1+\frac{1}{2}}$ V
- 0 - 2 V, $3\frac{1}{2}$ dual slope integrating type DVM reading = 1 volt

$= \underline{1}.\underline{0}\,\underline{0}\,\underline{0}$ volt

—— x ——

Que:- A $3\frac{1}{2}$ digit with 200 mv full scale digital voltmeter has an accuracy specification of $\pm$(0.5 % of reading + 5 count). If the meter reads 100 mv, the voltage being measured is ______.

ⓐ Any value bet^n 99.5 mv and 100.5 mv.

ⓑ Exactly 99.5 mv.

ⓒ Any value bet^n 99.0 mv and 101.0 mv.

ⓓ Exactly 100 mv.

sol^n:- $3\frac{1}{2}$ digit DVM, 100mv reading on 200mv.

Accurate specification: ± [0.5 % of reading plus 5 counts]

$$\rightarrow \text{error} = \frac{0.5}{100} \times \underset{\substack{100\text{mv range} \\ (200\text{mv})}}{\underline{1}\,\underline{0}\,\underline{0}\,.\,\underline{0}}\ \text{mv} + 5 \times \underset{\substack{100\text{mv range} \\ (200\text{mv})}}{\underline{0}\,\underline{0}\,\underline{0}\,.\,\underline{1}}\ \text{mv}$$

$$= \frac{0.5}{100} \times 100\text{mv} + 5 \times 0.1\ \text{mv}$$

$$= \pm(0.5\text{mv} + 0.5\text{mv}) = \pm(1\text{mv})$$

$$\Rightarrow V_m = 100\text{mv} \pm 1\text{mv} \equiv \boxed{99\text{ mv to } 101\text{mv}}$$

—x—

Que:- over ranging on DVM implies that, ________ digits are switched on.

(a) all full digits switched on.
(b) $\frac{1}{2}$ digits switched on.
'' . off .
(c) '' '' ''
(d) All full digits are switched off.

—x—

Que:- A $3\frac{1}{2}$ digit digital multimeter can display ________ .
(a) 999.5 (b) 1.999
(c) 5.999 (d) 555.5

sol^n:- 1.999

—x—

Que:- A dual slope A to D converter uses a n-bit counter when the i/p signal V_A is being integrated, the counter is allowed to count up to ___

(a) 2^N (b) $2^N - 1$

Que: Digital measuring instrument use following 3 types A/D converter

① Dual slope.
② counter type:
③ Flash "

The correct sequence for three converter in decreasing order of their speed.

Sol^n: ① Flash type (fastest)
② successive Approx type (next fastest)
③ counter type.
④ Ramp type.
⑤ Dual slope type. (slowest)

Non-integrating type.

speed↓, ⇒ conversion Time ↑

Integrating type design

Que:- Assertion: Dual slope ADC is the most prefer conversion approach in digital multimeter.

Reason: Dual slope A/D converter ~~high~~ provides high accuray in A/D conversion, which at the same time suppress the noize affect on the i/p signal.

Sol^n: True (Ass)
True (~~Ass~~ Reas)

"R" is correct explanation of "A"

Que: Integrating principle in the digital measurement is the conversion of ——.

(a) voltage to time. (Dual slope Type.)

(b) voltage to frequency.

(c) voltage to current.

(d) current to voltage.

Que: The reference (Vref) voltage and i/p (Vm) voltage are sequentially connected to the integrator with the help of a switch in a ——.

Ans: Dual slope type ADC.

—x—

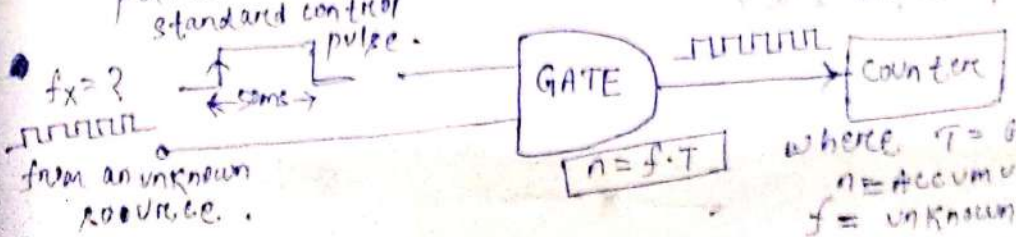
Que: An integrating DVM measures ——.

Soln: Average value. (BCZ of integration).

—x—

Que: A frequency counter with a gating time of 50 ms, counts 1254 cycles of an i/p square wave. Then the frequency of the i/p wave is ——.

Soln: Electronic counter is a measuring unit used for measurement of either frequency (or) time related parameters.



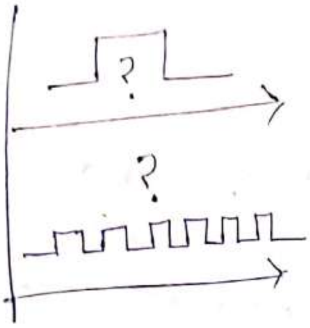
$\boxed{n = f \cdot T}$

where T = Gate open Time.
n = Accumulated count.
f = unknown (event rate) frequency.

$$\therefore f = \frac{n}{T} = \frac{1254 \overset{cycles}{\cancel{pulses}}}{50\ ms}$$

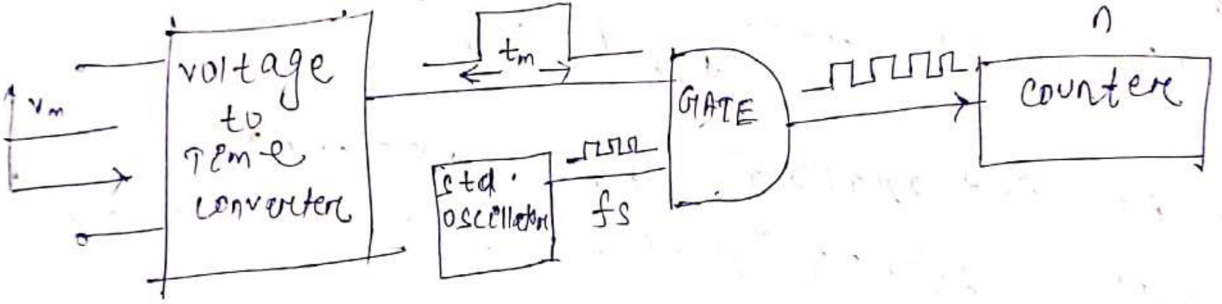
$$\Rightarrow f = 25.08\ KHZ$$

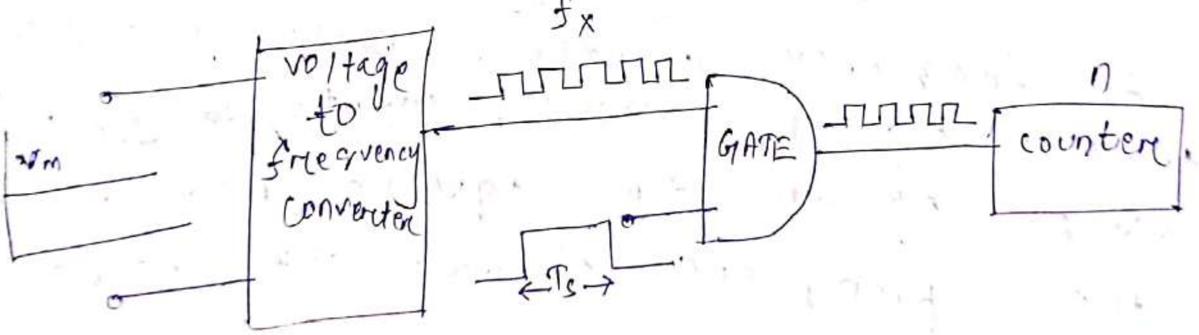
NOTE :- 2 basic measurements using Electronic counter (or) frequency counter.

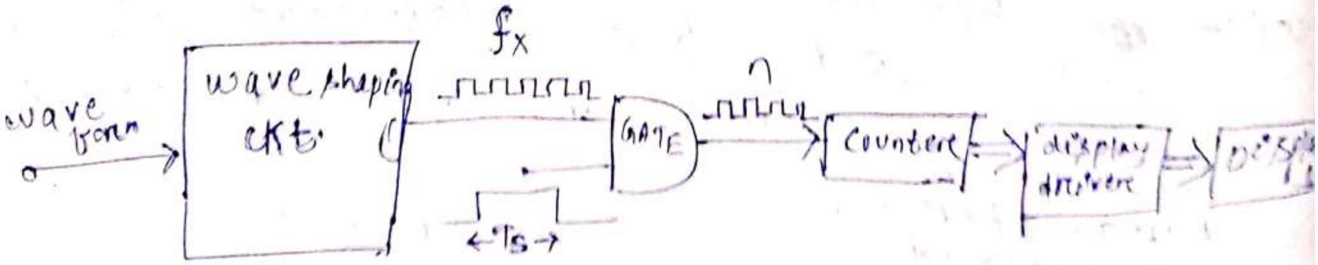


$T = n/f$

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







— x —