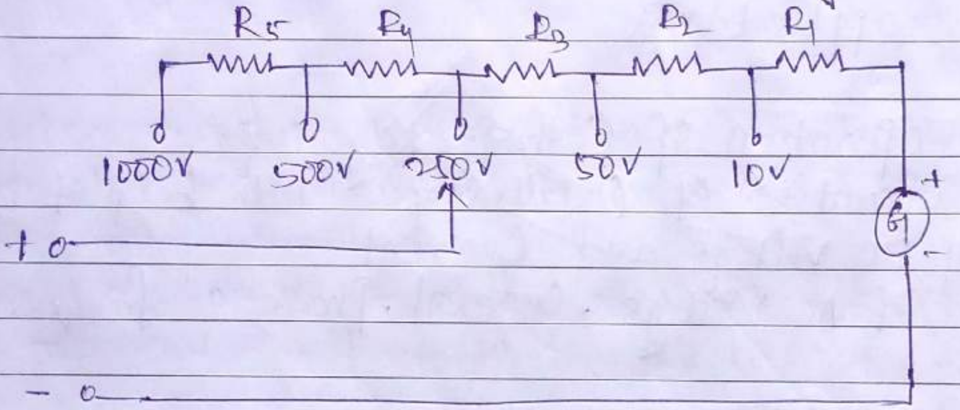
Principle and Construction of Multimeter

Multimeter is an instrument using which voltage, current and resistance can be measured. It has a function switch, which can be used to connect appropriate circuit for measurement of different quantities. It is also called "volt-ohm-milli-ammeter" (VOM) meter.

Voltage Measurement by Multimeter

A galvanometer can be used as a voltmeter by connecting series resistance as shown in the figure



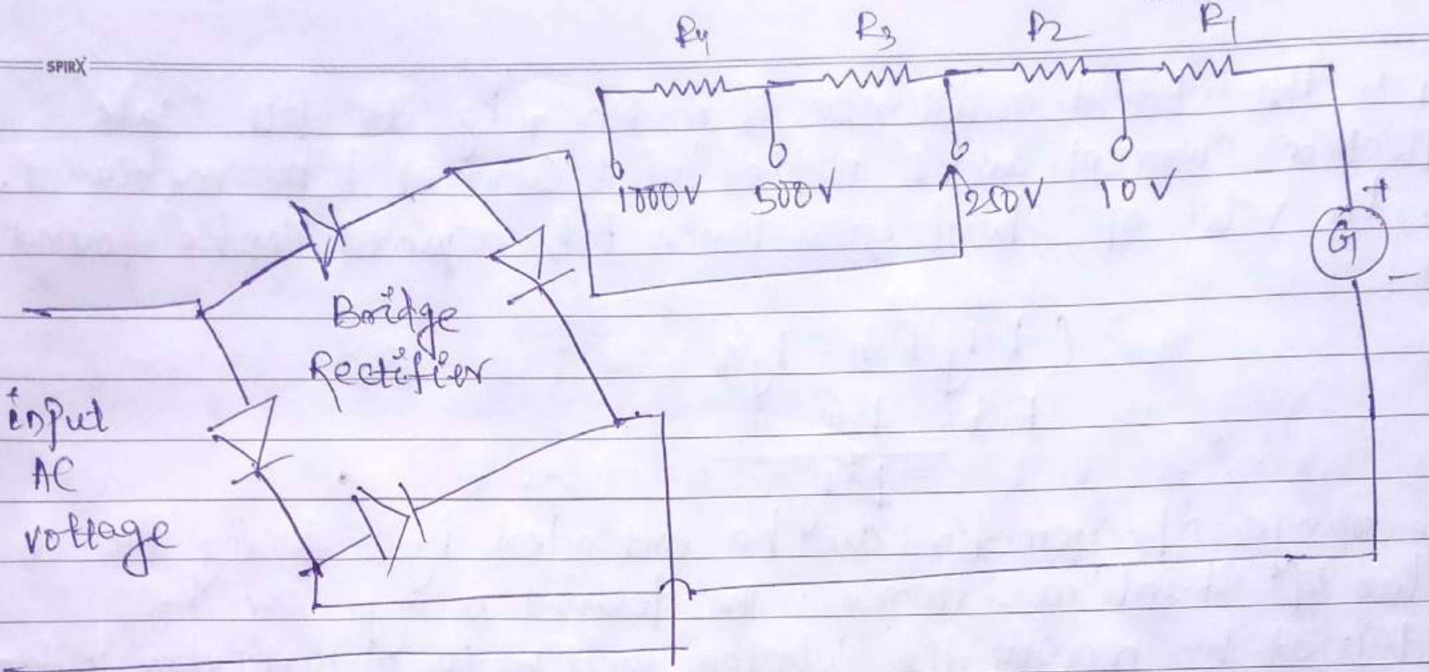
If the Galvanometer resistance is denoted by 'G' and 'Ig' is the full scale deflection current and the voltage to be measured is 'V' volts, then the value of series resistance 'Rs' is ~~den~~ determined as

$$V = I_g R_s + I_g G$$

$$\Rightarrow R_s = \frac{V - I_g G}{I_g}$$

The resistance is also called multiplier. The voltage range can be increased by increasing the value of multipliers.

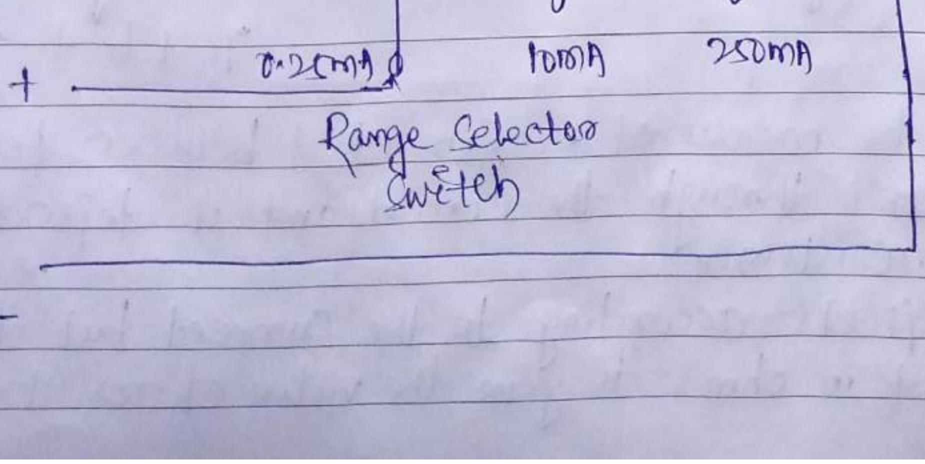
* The ~~multiplier~~ multimeter can also measure Ac. for this purpose, a full wave rectifier can be connected which converts Ac to DC for the application to galvanometer as shown in below figure.



Current M. → While using Analog Multimeter as a Voltmeter it must be connected Parallel with the Portion of the Circuit across which the voltage is being measured.

Current Measurement by Multimeter

» The Same Galvanometer Can be used for measuring Current when it is converted into an ammeter by Connecting a Small resistance Rsh in Parallel with the meter as shown in figure



If 'G' is the internal resistance of meter, 'Ig' its full scale deflection current and 'I' is the total current to be measured, then the value of shunt resistance Rsh required can be found as

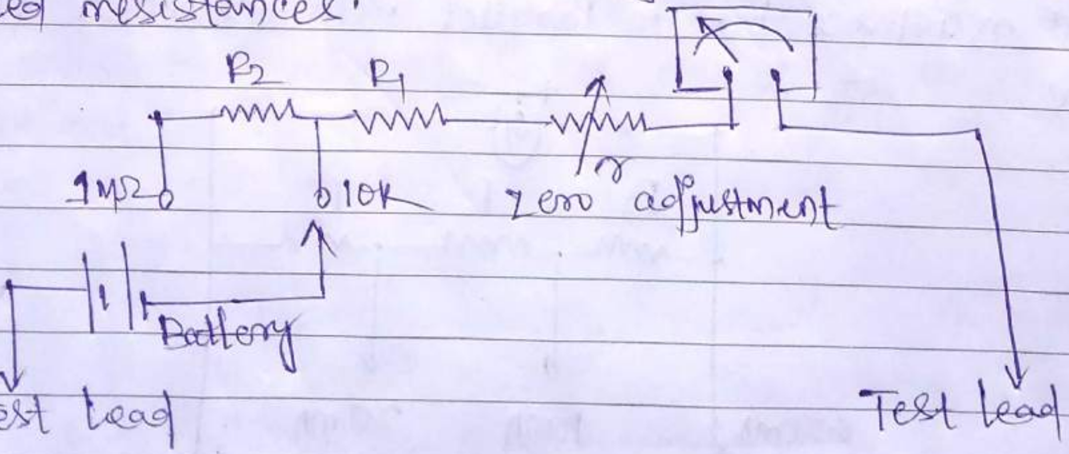
$$\Rightarrow (I - I_g) R_{sh} = I_g G$$

$$\Rightarrow R_{sh} = \frac{I_g G}{I - I_g}$$

- The range of ammeter can be extended by reducing the value of shunt resistance. The desired range can be obtained by moving the selector switch to a particular position.
- when using Multimeter as an ammeter, it must be connected in series with the branch in which current to be measured.

Resistance Measurement by Multimeter

The same instrument can be used as an ohmmeter to measure resistances. In this circuit, an internal battery is connected in series with the meter through a variable resistance 'r' and fixed resistances.



- The resistance to be measured is connected between test leads. Current flows through the circuit and it depends on the measuring resistance.
- Galvanometer deflects according to the current but the scale is calibrated in ohms to give the value of resistance directly.

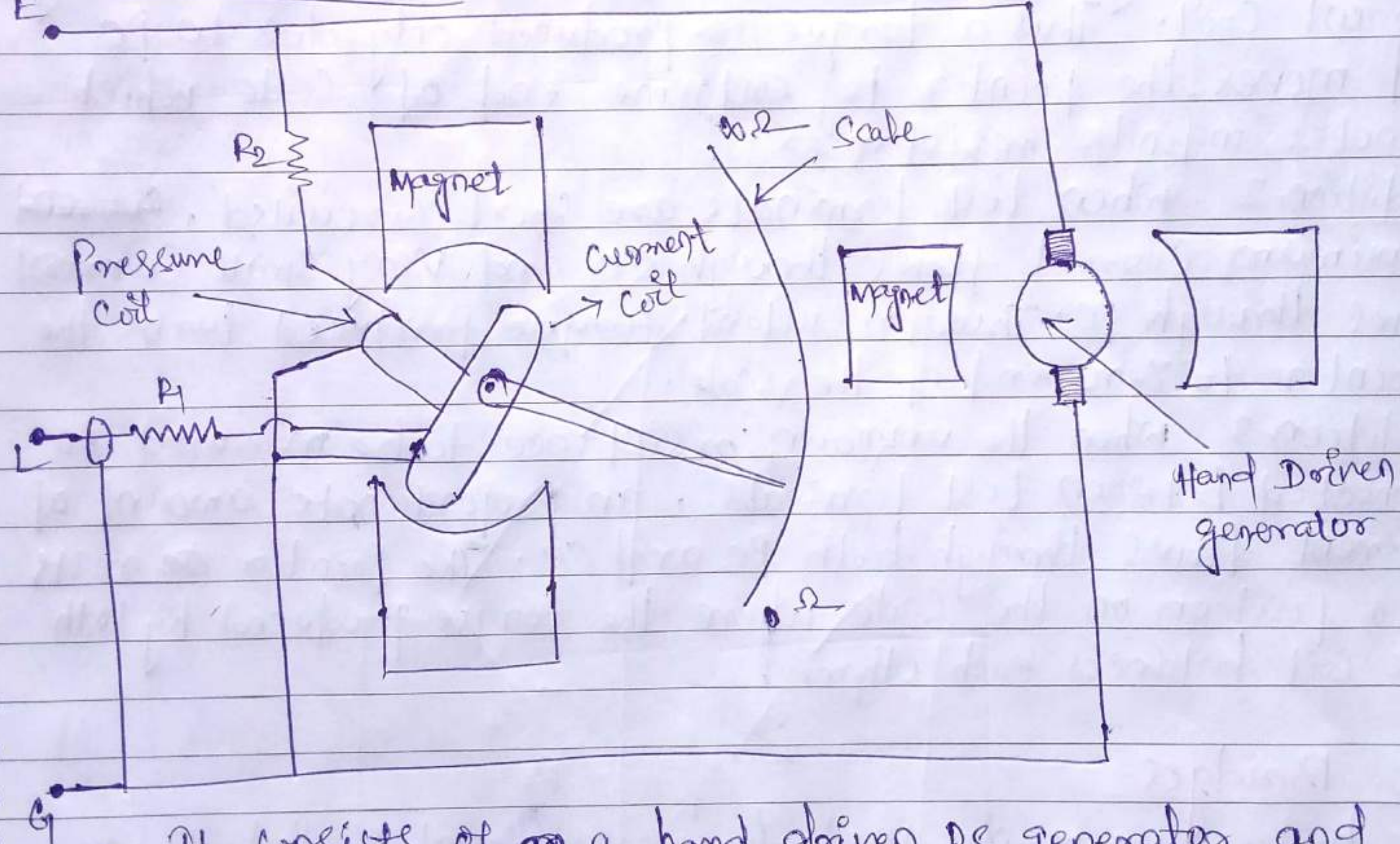
Construction and Principle of operation of Megger

Megger is an instrument used for measuring high resistances of the order of megaohms and for testing the insulation resistance.

Megger working Principle

When a current ~~carrying~~ carrying conductor is placed in a magnetic field, a mechanical force is experienced by it.

Construction



- It consists of a hand driven DC generator and a direct reading ohm meter.
- There are two coils, Pressure and Current coil which are fixed together at some angle and are free to rotate between the poles of a permanent magnet.
- Resistances R_1 and R_2 are connected in series with Current and Pressure coil to limit current.
- Guard ring is provided to shunt leakage current over the test terminals.

Date

Working :-

The resistance under test is connected between test terminals 'L' and 'G'. The generator handle is then steadily turned till the pointer gives a steady reading.

Three conditions can be analysed in order to understand the working

Cond-1 When the test terminals are open, the generator sends current through potential coil and no current flows through current coil. Thus a torque is produced only due to PC and moves the pointer to extreme end of scale which denotes infinite resistance.

Condition-2 When test terminals are short circuited, ~~current~~ maximum current flows through CC and very small current flows through PC. Thus resultant torque produced turns the pointer to zero end of the scale.

Condition-3 When the unknown resistance to be measured is connected between test terminals, an proportionate amount of current flows through both PC and CC. The pointer ~~be~~ rests in a position on the scale where the torque produced by both the coil balances each other.

Ac Bridges

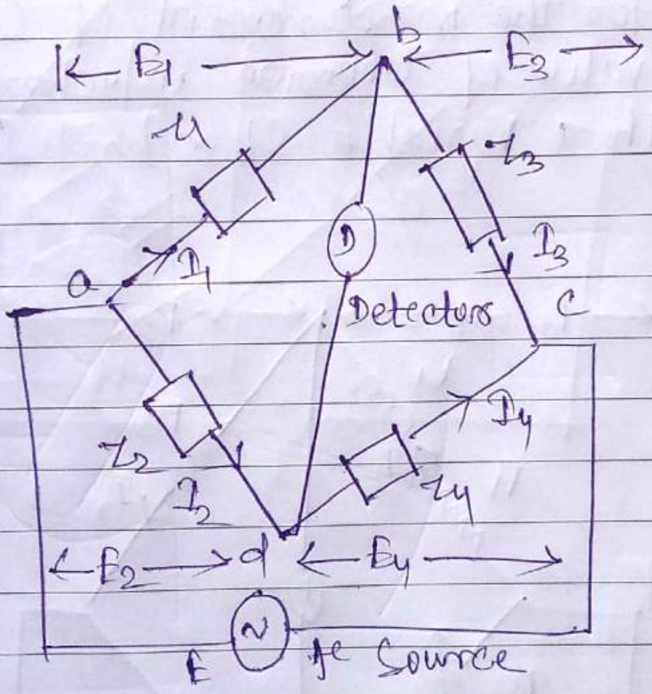
Ac bridges are mainly used for measurement of inductance, capacitance, loss factor etc.

Unlike wheatstone bridge, it consists of four arms, a source of excitation and a balance detector.

Out of four arms, two arms impedances are kept constant, one arm is made variable and an unknown impedance is connected between fourth arm.

Different detectors are used mainly depends on the frequency of operation. They are
(i) Head Phones (frequency range 250Hz to 4KHz)
(ii) vibration Galvanometer (frequency range 5Hz to 1000Hz)
(iii) Tuneable amplifier Detector (frequency range 10Hz to 100KHz)

General Equation of Bridge Balance



At balance condition, no current flows through the detector.
Thus $I_1 = I_3$ and $I_2 = I_4$
which means potential across point 'b' and 'd' are equal.
So $\Rightarrow V_{ba} = V_{da}$

$\Rightarrow E_1 = E_2$

$\Rightarrow I_1 Z_1 = I_2 Z_2$

$\Rightarrow \frac{E}{Z_1+Z_3} \times Z_1 = \frac{E}{Z_2+Z_4} \times Z_2$ i.e $I_1 = \frac{E}{Z_1+Z_3}$

$I_2 = E/Z_2+Z_4$

$\Rightarrow \frac{Z_1}{Z_1+Z_3} = \frac{Z_2}{Z_2+Z_4}$

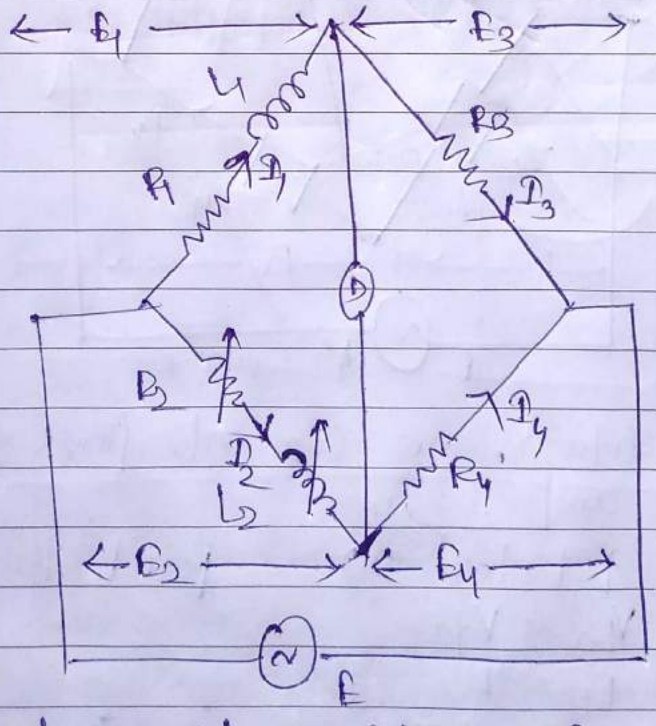
$\Rightarrow Z_1Z_2 + Z_1Z_4 = Z_1Z_2 + Z_2Z_3$

$\Rightarrow \boxed{Z_1Z_4 = Z_2Z_3}$ Condition of balance.

Measurement of Inductance by Maxwell's Bridge Method

The bridge used for the measurement of self inductance of the circuit. The value of unknown inductance is determined by comparing it with a variable standard self inductance.

Circuit Diagram:-



$L_1 \rightarrow$ Unknown inductance of resistance R_1

$L_2 \rightarrow$ Variable inductance

$R_2 \rightarrow$ variable resistance connected in series with inductor L

$R_3, R_4 \rightarrow$ known non inductive resistance.

Impedances of four arms are

$Z_1 = R_1 + j\omega L_1$

$Z_2 = R_2 + j\omega L_2$

$Z_3 = R_3$

$Z_4 = R_4$

At balance condition $\Rightarrow Z_1 Z_4 = Z_2 Z_3$

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

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

Comparing real part

$\Rightarrow R_1 R_4 = R_2 R_3$

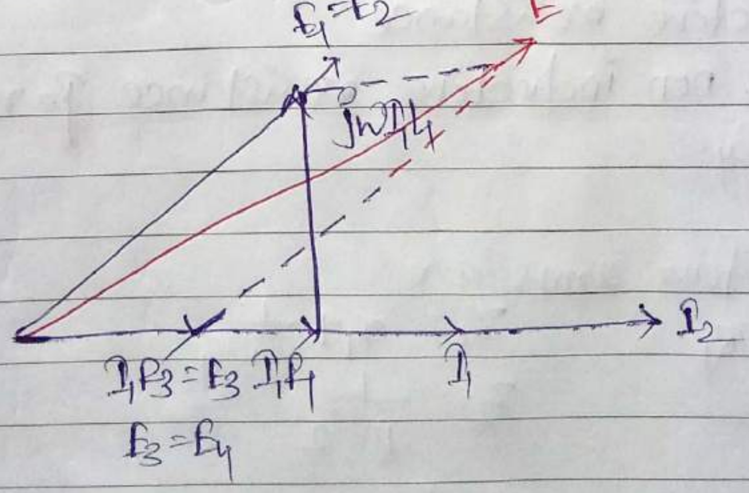
$$\boxed{\Rightarrow R_1 = \frac{R_2 R_3}{R_4}}$$

Comparing imaginary part

$\Rightarrow j\omega L_1 R_4 = j\omega L_2 R_3$

$$\boxed{\Rightarrow L_1 = \frac{L_2 R_3}{R_4}}$$

Phasor Diagram



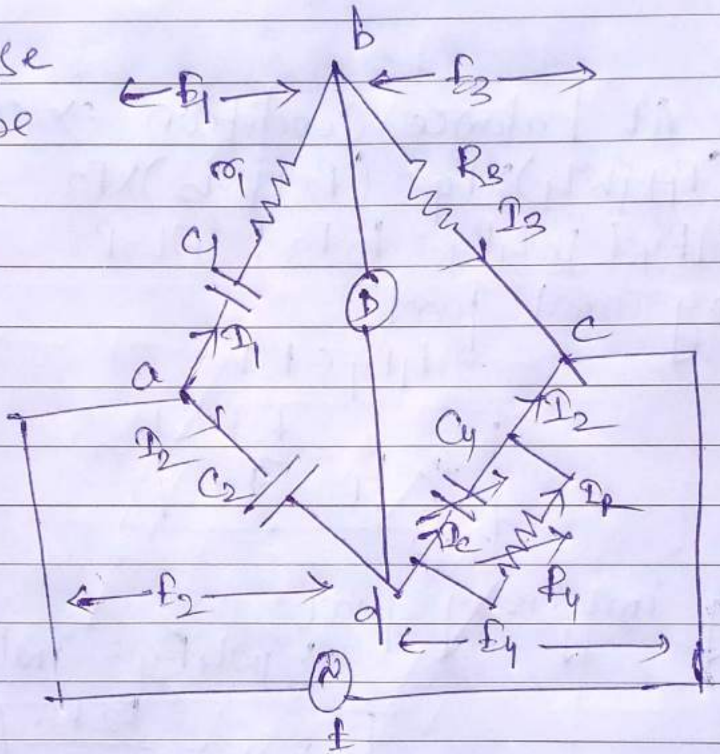
Measurement of Capacitance by Schering Bridge Method

It is the most commonly used bridge for measurement of Capacitance.

Circuit Diagram

Let C_1 → Capacitor whose Capacitance is to be determined.

r_1 → Series resistance representing loss resistance of capacitor C_1



C_2 → A Standard Capacitor

C_4 → A variable Capacitor

R_3 → A non inductive resistance

R_4 → A variable non inductive resistance parallel to variable capacitor C_4.

Impedances of four arms are

~~$Z_1 = r_1 - j/\omega C_1$~~

~~$Z_2 = -j/\omega C_2$~~

$$Z_1 = r_1 + \frac{1}{j\omega C_1}$$

$$Z_2 = \frac{1}{j\omega C_2}$$

$$Z_3 = R_3$$

$$Z_4 = \frac{R_4 \times \frac{1}{j\omega C_4}}{R_4 + \frac{1}{j\omega C_4}} = \frac{R_4}{1 + j\omega C_4 R_4}$$

At balance condition

$$\Rightarrow Z_1 Z_4 = Z_2 Z_3$$

$$\Rightarrow \left(r_1 + \frac{1}{j\omega C_1}\right)\left(\frac{R_4}{1+j\omega C_4 R_4}\right) = \frac{1}{j\omega C_2} \times R_3$$

$$\Rightarrow \left(r_1 + \frac{1}{j\omega C_1}\right) \times R_4 = \frac{R_3}{j\omega C_2} \times \left(1 + j\omega C_4 R_4\right)$$

$$\Rightarrow r_1 R_4 + \frac{R_4}{j\omega C_1} = \frac{R_3}{j\omega C_2} + \frac{R_3 C_4 R_4}{C_2}$$

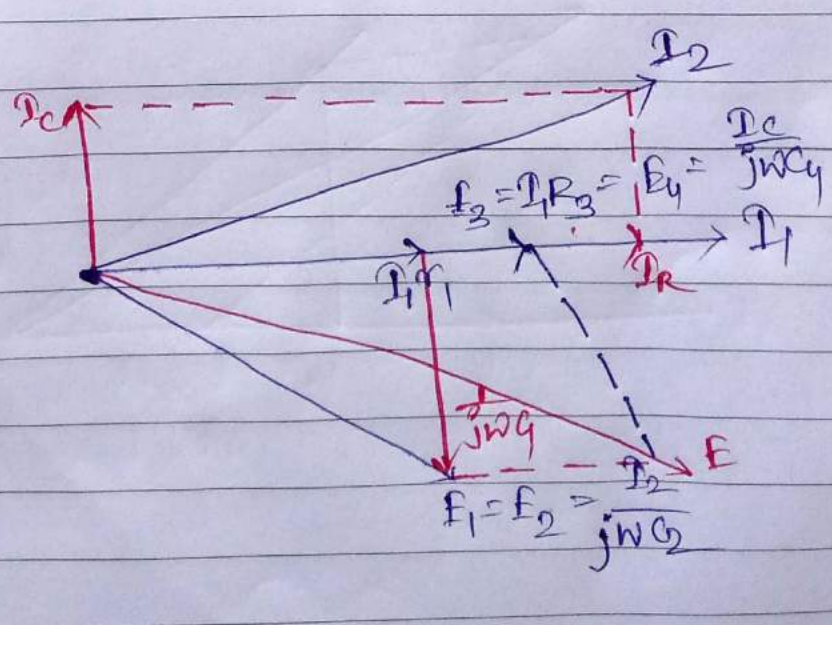
Comparing real part $\Rightarrow r_1 R_4 = \frac{R_3 C_4 R_4}{C_2}$

$$\boxed{\Rightarrow r_1 = \frac{R_3 C_4}{C_2}}$$

Comparing imaginary part $\Rightarrow \frac{R_4}{j\omega C_1} = \frac{R_3}{j\omega C_2}$

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

Phasor Diagram



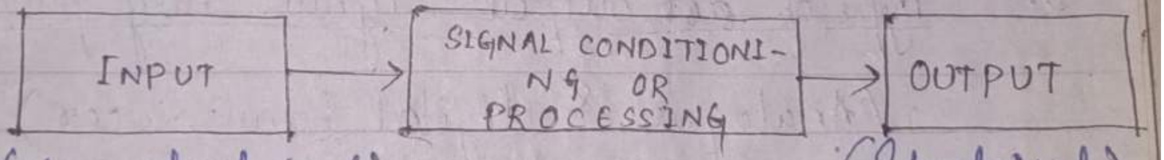
13/10/

TRANSDUCER

*. It is basically measuring the non-electrical quantities in terms of electrical standards.

*. A transducer/ sensor is a device which measures the non-electrical quantities like temp, pressure, force, displacement in terms of electrical standards.
— (1 mark)

*. A transducer is consisting of 3 components
- Input device
- Signal conditioning or processing
- Output



(Non-electrical) (Electrical)

*. There are 3 types of Classification

1. <u>On the basis of application</u> :-
(primary transducer, secondary transducer)

A transducer senses a signal directly then it is known as PRIMARY TRANSDUCER.

If the i/p signal is primarily sensed by a detector or sensor and

Eg:- Thermistor

~~1456 Transducer~~.

then it is given to the transducer then it is known as SECONDARY TRANSDUCER.

2. On the method of energy conversion:-

(Active & passive transducer)

If the transducer generalis the o/p in the form of electricafl voltage or current ~~then it is known~~ without any auxillary source, then it is known as ACTIVE TRANSDUCER. Eg:- Piezoelectric accelerome Eg:- Sec. transformer, thermocouplee

If the non-electrical quantities are mearing by influence of a ext! source, then it is PASSIVE TRANSDUCER

Eg:- Streain gauge, resistance temperature defectore (RTD's) & theremistore

3. Type of ~~out~~ output signal they produce:-

(Analogue & digital transducer)

Analogue transducers give the o/p which is a continiou function of time.

Eg:- Theremistord, LVDT, thermocouple, straingauge etc.

Digital transducer gives the o/p which is diskreele function of time. or pulse

Eg:- Tachometer

These digital treansducerce are becoming more popular nowadays because due to the fact that digital signale can be treansmited over a long distance without causing much distortion due to amplitude variation & Phase sh

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Hint { LVDT - linear va
full form

THERMIST
It is a tran
value in te

Temp

It is very
effective
detector
Thermistor
semicondu
unique
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i.e T

There are
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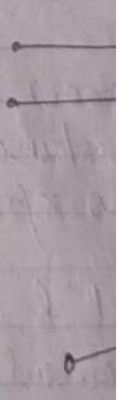


first full form { LVDT - Linear variable voltage transformer }

THERMISTOR :-

It is a transducer which measures temperature in terms of current.

Temp ⟶ Resistance ⟶ Current

It is very much sensitive device and more effective than resistance temperature detector (RTD).

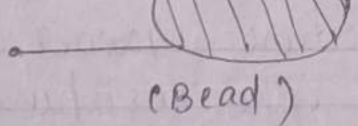
Thermistor is basically consisting of semiconducting materials having an unique property -ve temperature coefficient of resistance.

$\boxed{\text{i.e } T\uparrow \rightarrow I\uparrow (1/\alpha . R\downarrow)}$

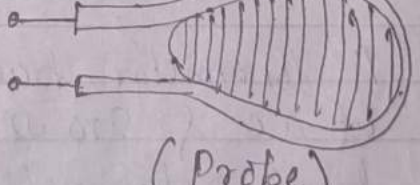
T = Temp.
R = Resistance
I = current

There are different thermistor available of various shape & size and basically composed of mixture of metallic oxide like Mn, Ni, CO, Cu, Fe and Uranium etc.

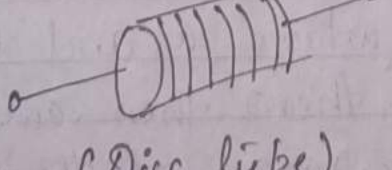
The resistance range of thermistor varies from 0.5Ω to 75 MΩ.



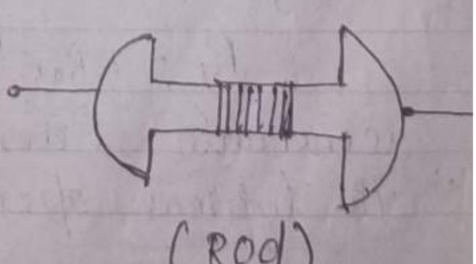
(Bead)



(Probe)



(Disc type)



(ROD)

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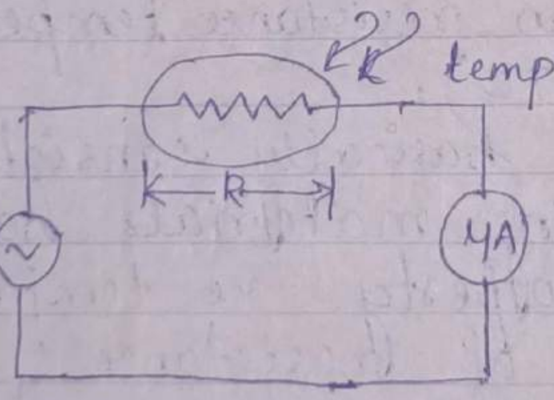
THERMISTOR :-

Basically the thermistor is used to measure the temperature by employing heat in a circuit as a linear resistor. The resistance of the resistor goes on varying in a -ve temperature coefficient relationship and succeedingly the surrounding temperature in the circuit can be easily measured.
~~Th~~

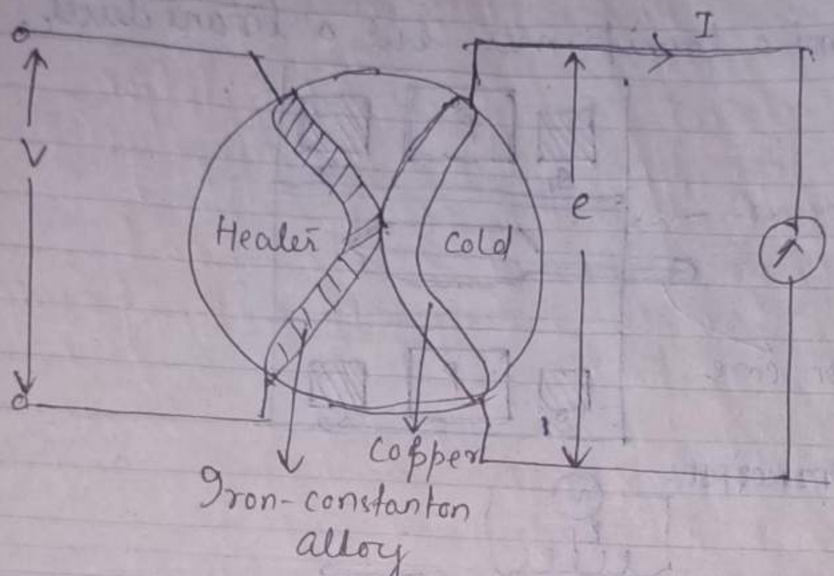


$$\boxed{R_1 = aR_0}$$

The representation of a thermistor is given by above equⁿ.

R_0 = resistance of the thermistor at 0°c or 273 K (T_0)
R_1 = final value of resistance
It is the changed resistance at T_1 which is the other absolute temp. T_1 than T_0 (may be more or less than T_0)

Thermocouple :



Constantan = Ni(45%) + Cu(55%)

There are two metals having different work function are placed together in a transformer principle. The junction which is formed is placed/kept in a sealed chamber in order to have no leakage of the temperature when the heat flows to the colder element. & subsequently produces EMF which produces current 'I' which is measured by the microammeter and ultimately we can say this transducer measured internal ckt temperature in terms of current.

Cold part is made up of Copper
heater part is made up of Iron- constanton alloy.

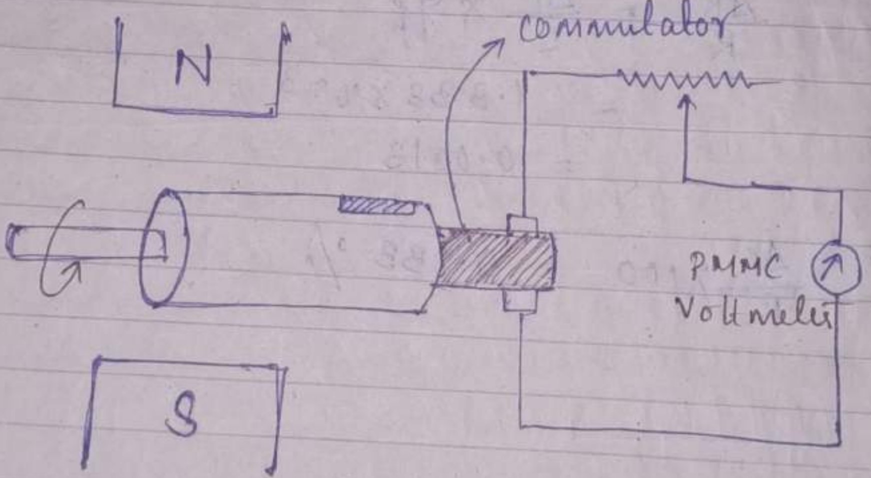
— Measurement of Torque by Tachometer

A Tachometer (Tachogenerator) is a device which is used to measure angular velocity There are two basic types of Tachometer availaible

ⓐ Electrical
ⓑ Digital.

→ Electrical :- ⓐ AC
ⓑ DC

DC Tachometer :-



ques

What is the relationship btw^{n} no load cond^{n} of a gen. which is coupouled with ~~[illegible]~~ the motor and load cond^{n} when the gen. connected to motor.

* It consisting of a small armature having a shaft which is to be coupled to a machine whose rotation we want to measure. It is having commutator and brush connected as shown.

* There is a secondary ckt which take care of the EMF generated

$$\boxed{E = \frac{P\phi ZN}{60A}}$$

* It is consisting of

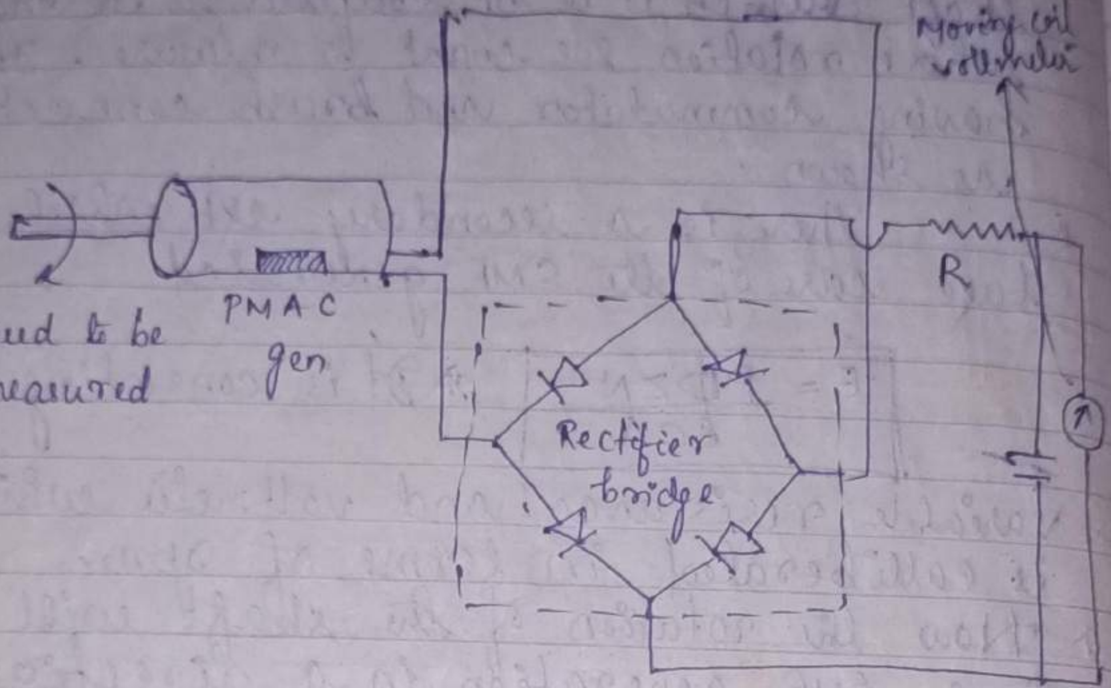
- variable resistance and voltmeter which is calliberated in terms of rpm.

* Now the rotation of the shaft will lead to a EMF generation in a direction proportion ($e \propto N$) which is ~~var~~ measured by the PMMC voltmeter with a less accuracy.

Disadvantages:-

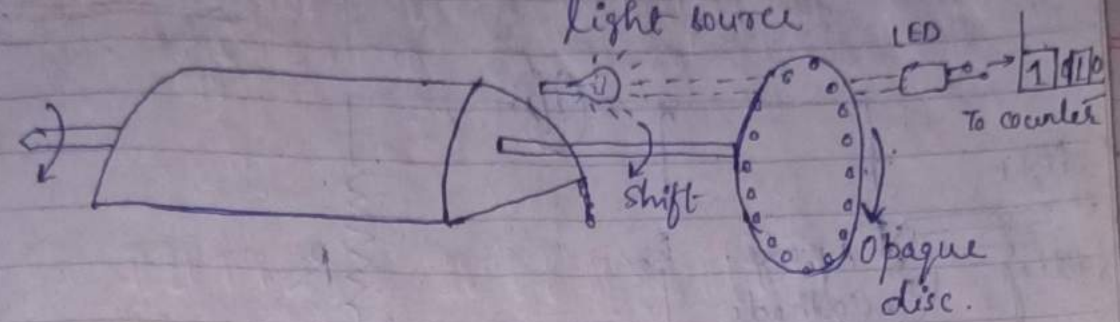
* The system is bulky, inefficient, does not give complete DC, and also Analogue type.

AC TACHOMETER :-



In this case PMAC ~~motor~~ gen (Permanent magnet AC gen) is used which causes an EMF to be induced on the secondary side which is proportional to the speed of rotation In order to get a better ~~ac~~ accuracy the o/p of the AC gen is fed to a rectifier bridge. The o/p of bridge rectifier (consist of 4 diode) is connected with R-C ckt which removes the ripple contents present in the signal (EMF) & the same is given to moving coil voltmeter which is calliberated in terms of speed to measure the xact amt of DC voltage.

(DIGITAL // PHOTOELECTRIC) TACHOMETER



ⓐ In this case an opaque disc is ~~also known as photoelectric tachometer~~ maunted on the rotating shaft. The disc has a no. of equidistant holes on its periphery when the opaque medium comes btwⁿ the path of the light source & LED as shown in the figure. The sensor is unilluminated & produces a LOW, NULL o/p.

ⓑ When the holes comes in btwⁿ the path we get an o/p high on the LED & a pulse is generated on the digital counter connected to the o/p of LED.

ⓒ The series of binary readings formulated via BCD gives a 7-segment display of the decimal rpm.

ⓓ This one is lighter & more efficient & less costly.

Imp

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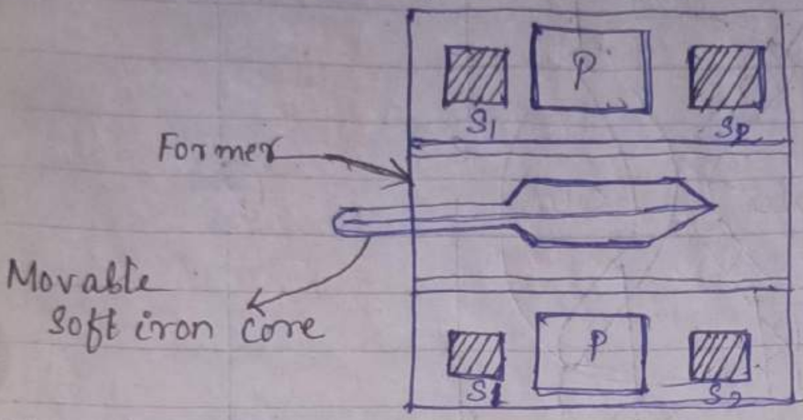
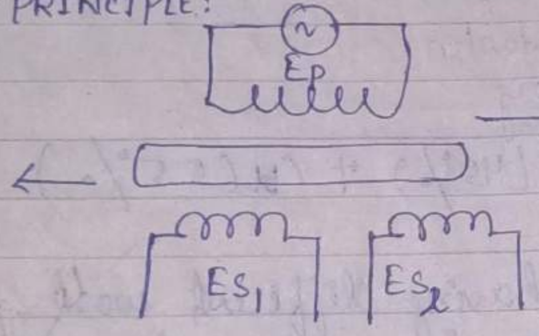
LINEAR Variable Differential Transformer [LVDT]

It is not a transformer but a transducer.



WORKING PRINCIPLE:



It is the most widely used inductive transducer which transduces the linear motion to EMF.

CONSTRUCTION:—

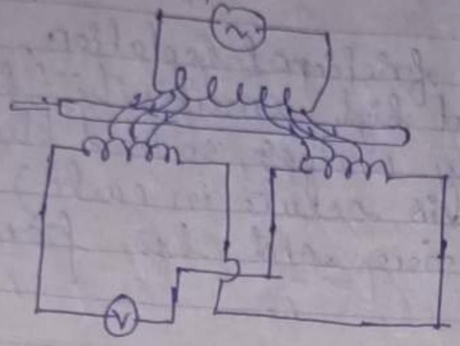
There is a transformer which is consisting of one primary windgs 'P' and two secondary windgs S_1 & S_2 surrounding the primary. S_1 & S_2 have equal no. of turns.

There is a movable soft iron core placed inside the 'former' (It is an housing). The iron core is having high permeability. It is made up of Nickel-iron alloy which is hydrogen annealed (sudden cooling given to hot iron & to solidify)

Annealed:- The hot material is cooled and hardened to strengthen the solid.

- The former is made up of stainless steel with proper shielding.

WORKING PRINCIPLE:-



$E_0 = E_{S_1} - E_{S_2}$ (resultant secondary EMF)

There is a differential o/p in the secondary

$$E_0 = E_{S_1} - E_{S_2}$$

The flux paths produced by the E_p are linked by the iron core which is placed in the magnetic medium.

(i) When the iron core is at middle position, the flux linking to both S_1 & S_2 are equal Hence $\boxed{E_{S_1} = E_{S_2}}$ and $\boxed{E_0 = 0}$ and we get not displacement in the core.

(ii) If the core is moving to left then more flux links S_1 and $\boxed{E_{S_1} > E_{S_2}}$ and E_0 is having a increasing +ve value.

(iii) If the core is moving to right then more flux links S_2 and $E_{S_2} > E_{S_1}$ and E_0 is having ~~decre~~ increasing -ve value.

Shrt Qns:

Advantage :- over ordinary transducer.

(i) High range for measurement of linear displacement.

(ii) Electrical and frictional isolation.

(iii) High i/p and high sensitivity (bcoz of two secondary windgs, so the flux accumulation is acute in each)

(iv) Low hysterisis and low power conservation.

Disadvantages :-

(i) Transducer performance can be affected by vibrations.

(ii) Ext. temp. effect is over the cu wire which leads to misguided result in EMF.

Note :-
In a gas filled type the transmission of e is much faster than vaccum type.

CAPACITIVE TRANSDUCER

* $\boxed{C = \epsilon_0 \frac{A}{d}}$

ϵ_0 = permitivity of medium
A = overlapping area in
d = distance btwn plates 2

* displacement is measured in terms of change in Farad.

$\epsilon = \epsilon_0 \times \epsilon_r$ $\epsilon_0 = 8.85 \times 10^{-12}$

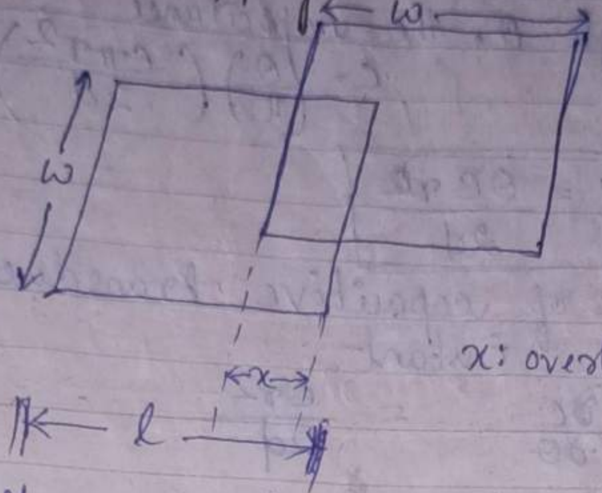
* A capacitive transducers uses the concept of parallel plate capacitor.

Imp In a parallel plate capacitor it transduces the displacement into change in capacitance which is caused due to

(i) Change in overlapping area
(ii) Change in distance btw the plate
(iii) Change in permitivity

Out of the above threes, the change in permitivity is less. Hence the total change in capacitance mainly depends upon 1st two points.

change in capacitance due to change in overlapping area:-



x: overlapping area.

The capacitance is directly proportional to overlapping area

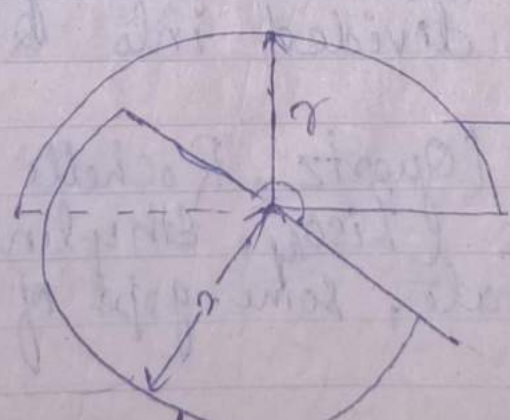
$$C = \frac{\epsilon A}{d} = \frac{\epsilon (w \times x)}{d}$$

$$C_{max} = \frac{\epsilon (w \times l)}{d}$$

Sensitivity of capacitive transducer at any instant is difined as

$$S = \frac{\partial C}{\partial x} = \frac{\epsilon w}{d}$$

For angular displacement of capacitive plate



$$C_{max} = \frac{\epsilon \pi r^2}{2d} , \quad C = \frac{\epsilon A}{d}$$

At any angle θ, the capacitance

$$C = \left(\frac{\theta}{\pi}\right)\left(\frac{\epsilon \pi r^2}{2d}\right)$$

$$\therefore \boxed{C = \frac{\theta \epsilon r^2}{2d}}$$

<u>Sensitivity</u>:- of capacitive transducer at any instant

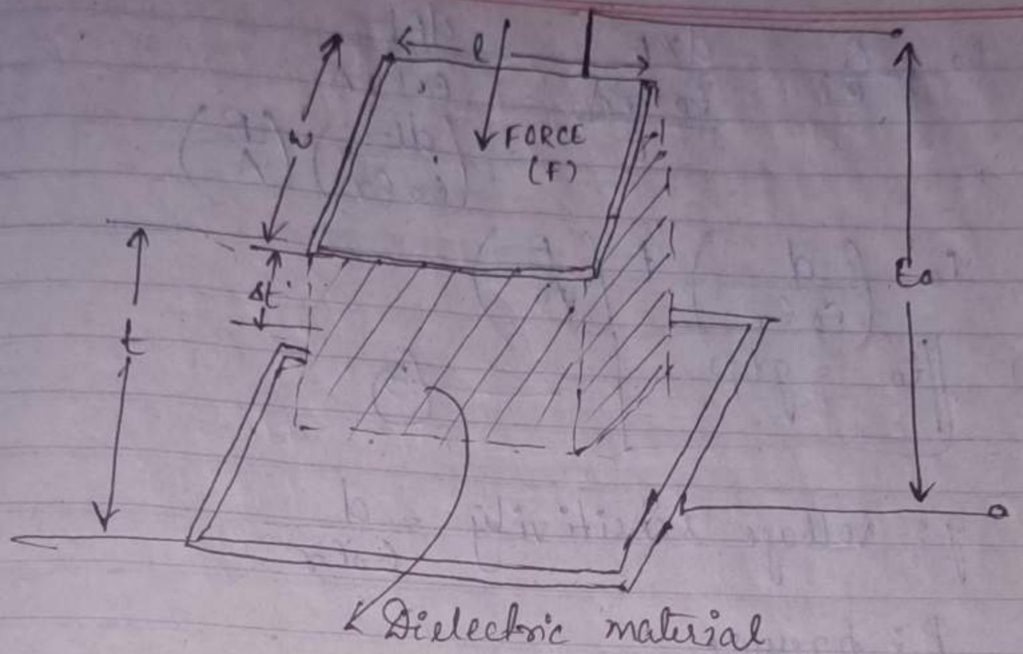
$$S = \frac{\partial C}{\partial \theta} = \frac{\epsilon r^2}{2d}$$

PIEZOELECTRIC TRANSDUCER

A piezo-electric material when subjected to stress, then the dimension of material changes which leads to electronic deformations within the atomic structure & later on, this leads to the rise of potential difference across the material and vice-versa. This phenomenon is known as piezoelectric effect. It is reversible process.

Some common materials showing piezo electric properties are divided into 2 grps

→ natural (Quartz, Rochelle salt)
→ synthetic ($LiSO_4$, Ethylene diamine tartarate, some grps of benzene



The charge which is developed due to deformation often lead to EMF

$$E_0 = Q/C$$

C : capacctance

Q: charge

$Q = d \times F$ — ①   d: charge sensitivity of a crystal coul/N.

F: applied force in N

$$Y \text{ (young's Modulus)} = \frac{\text{stress}}{\text{strain}}$$

$$= \frac{F/A}{\Delta t/t}$$

$$F = \left(\frac{A Y}{t}\right) \Delta t \text{ — ②}$$

$A = w \times l$

Hall Effect Transducer

Definition: The **hall effect** element is a type of transducer used for **measuring** the **magnetic field** by **converting** it into an **emf**. The direct measurement of the magnetic field is not possible. Thus the Hall Effect Transducer is used. The **transducer converts** the **magnetic field** into an **electric quantity** which is easily **measured** by the **analogue** and **digital meters.**

Principle of Hall Effect Transducer

The principle of hall effect transducer is that if the current carrying strip of the conductor is placed in a transverse magnetic field, then the EMF develops on the edge of the conductor. The magnitude of the develop voltage depends on the density of flux, and this property of a conductor is called the Hall effect. The Hall effect element is mainly used for magnetic measurement and for sensing the current.

The metal and the semiconductor has the property of hall effect which depends on the densities and the mobility of the electrons.

Consider the hall effect element shown in the figure below. The current supply through the lead 1 and 2 and the output is obtained from the strip 3 and 4. The lead 3 and 4 are at same potential when no field is applied across the strip.

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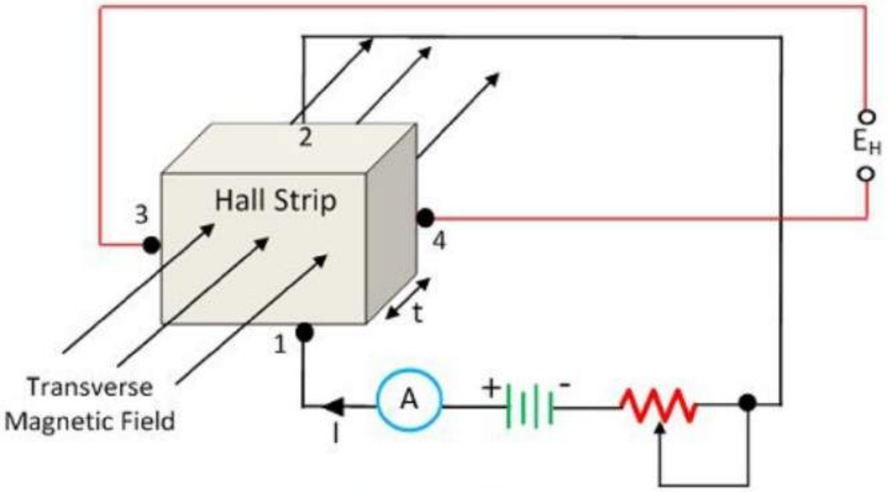


Hall Effect Element

Circuit Globe

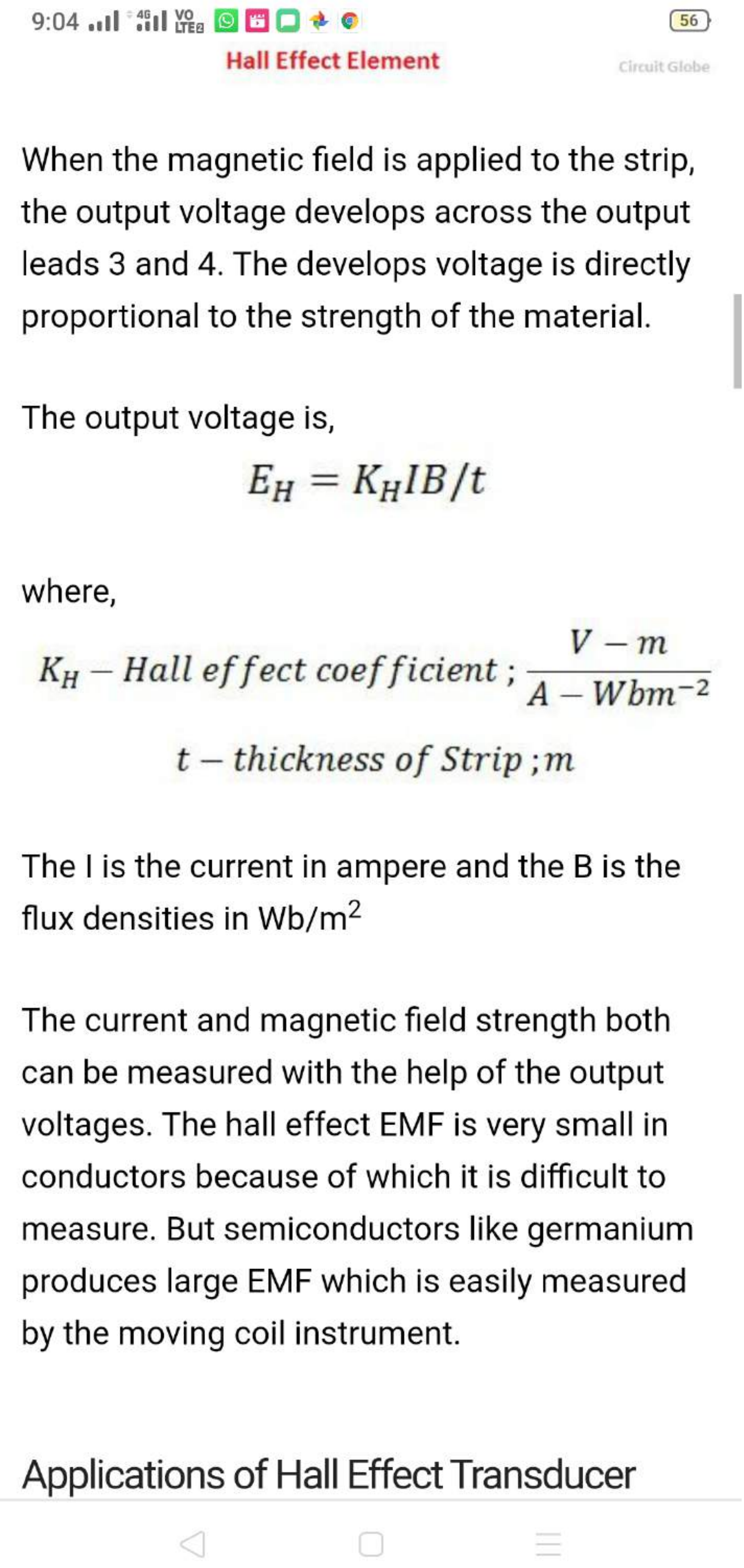
When the magnetic field is applied to the strip, the output voltage develops across the output leads 3 and 4. The develops voltage is directly proportional to the strength of the material.

The output voltage is,

$$E_H = K_H IB/t$$

where,

$$K_H - Hall\ effect\ coefficient : \frac{V - m}{}$$



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The output voltage is,

$$E_H = K_H IB/t$$

where,

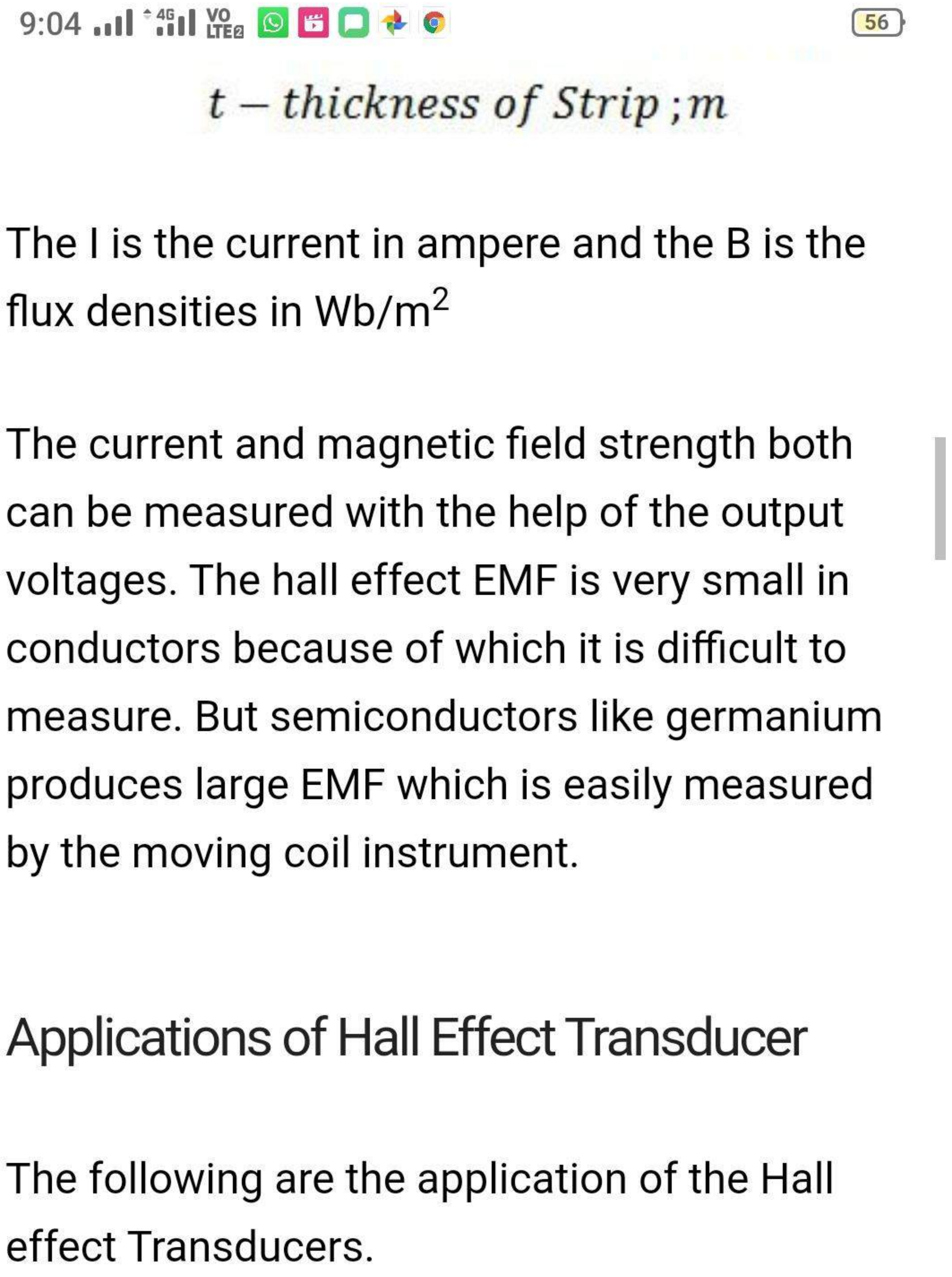
$$K_H - Hall\ effect\ coefficient\ ;\ \frac{V-m}{A-Wbm^{-2}}$$

$$t - thickness\ of\ Strip\ ;m$$

The I is the current in ampere and the B is the flux densities in Wb/m^2

The current and magnetic field strength both can be measured with the help of the output voltages. The hall effect EMF is very small in conductors because of which it is difficult to measure. But semiconductors like germanium produces large EMF which is easily measured by the moving coil instrument.

Applications of Hall Effect Transducer



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Applications of Hall Effect Transducer

The following are the application of the Hall effect Transducers.

1. Magnetic to Electric Transducer – The Hall effect element is used for converting the magnetic flux into an electric transducer. The magnetic fields are measured by placing the semiconductor material in the measurand magnetic field. The voltage develops at the end of the semiconductor strips, and this voltage is directly proportional to the magnetic field density.

The Hall Effect transducer requires small space and also gives the continuous signal concerning the magnetic field strength. The only disadvantage of the transducer is that it is highly sensitive to temperature and thus calibration requires in each case.

2. Measurement of Displacement – The Hall effect element measures the displacement of the structural element. **For example –** Consider the ferromagnetic structure which has a permanent magnet.

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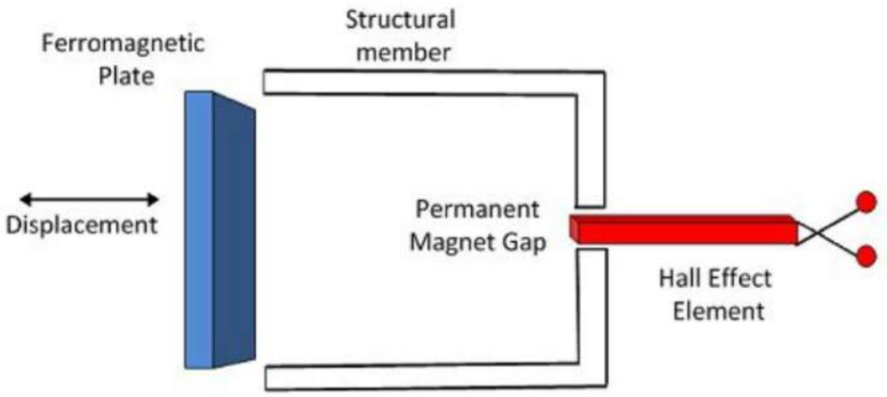


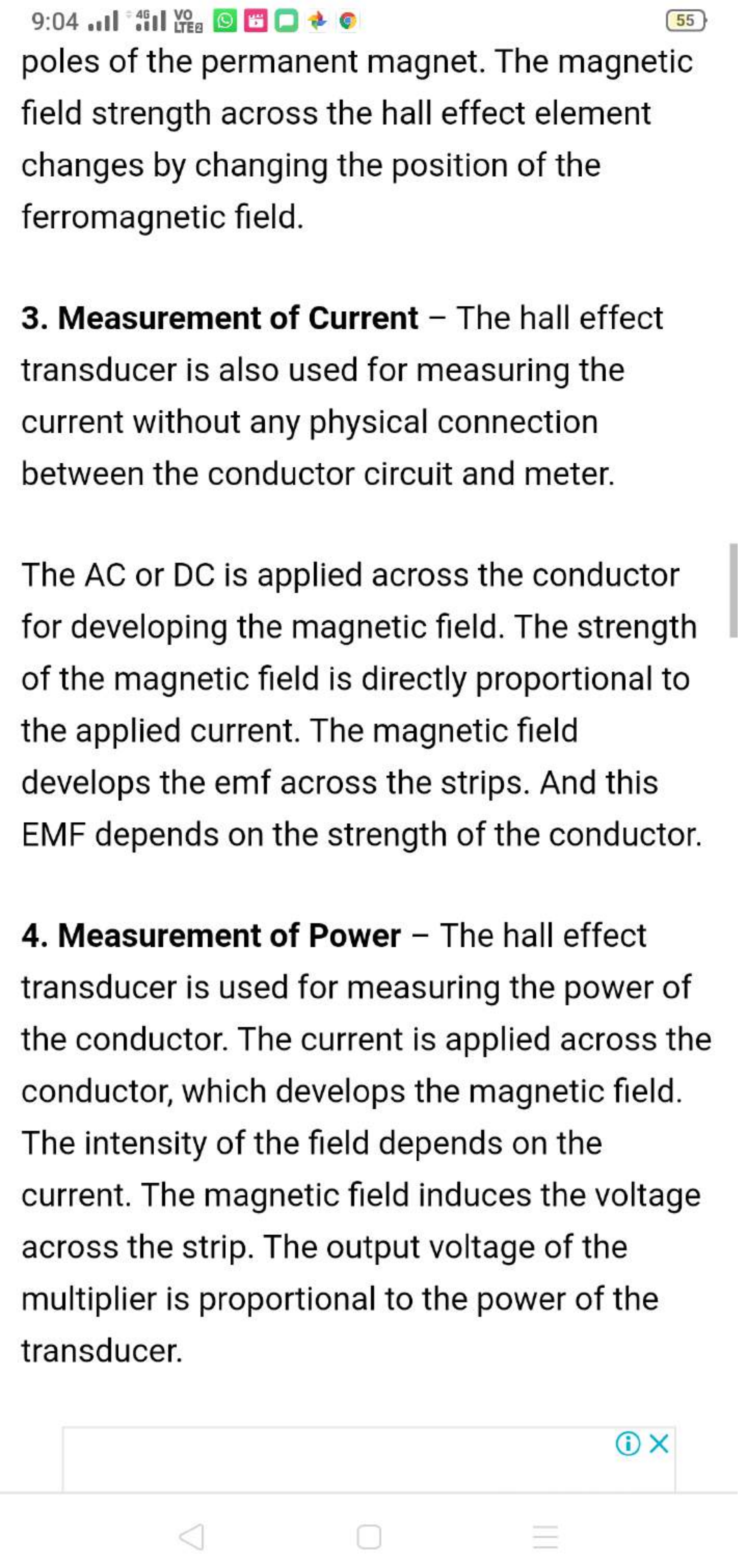
Measurement of Displacement Using Hall Efect Transducer

Circuit Globe

The hall effect transducer placed between the poles of the permanent magnet. The magnetic field strength across the hall effect element changes by changing the position of the ferromagnetic field.

3. Measurement of Current – The hall effect transducer is also used for measuring the current without any physical connection between the conductor circuit and meter.

The AC or DC is applied across the conductor for developing the magnetic field. The strength



poles of the permanent magnet. The magnetic field strength across the hall effect element changes by changing the position of the ferromagnetic field.

3. Measurement of Current – The hall effect transducer is also used for measuring the current without any physical connection between the conductor circuit and meter.

The AC or DC is applied across the conductor for developing the magnetic field. The strength of the magnetic field is directly proportional to the applied current. The magnetic field develops the emf across the strips. And this EMF depends on the strength of the conductor.

4. Measurement of Power – The hall effect transducer is used for measuring the power of the conductor. The current is applied across the conductor, which develops the magnetic field. The intensity of the field depends on the current. The magnetic field induces the voltage across the strip. The output voltage of the multiplier is proportional to the power of the transducer.

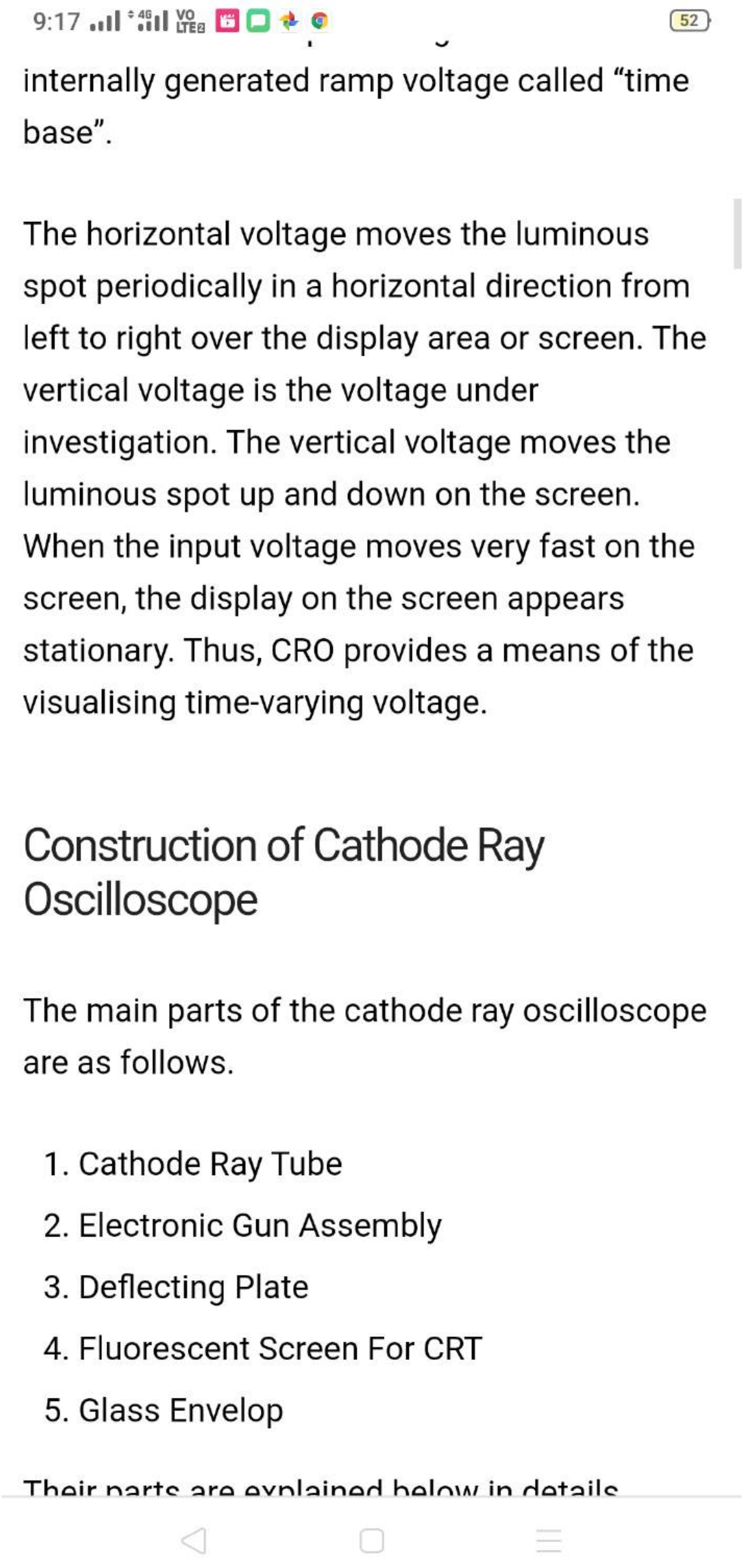
Cathode Ray Oscilloscope (CRO)

Definition: The cathode ray oscilloscope (CRO) is a type of electrical instrument which is used for showing the measurement and analysis of waveforms and others electronic and electrical phenomenon. It is a very fast X-Y plotter shows the input signal versus another signal or versus time. The CROs are used to analyse the waveforms, transient, phenomena, and other time-varying quantities from a very low-frequency range to the radio frequencies.

The CRO is mainly operated on voltages. Thus, the other physical quantity like current, strain, acceleration, pressure, are converted into the voltage with the help of the transducer and thus represent on a CRO. It is also used for knowing the waveforms, transient phenomenon, and other time-varying quantity from a very low-frequency range to the radio frequencies.

The CRO has Stylus (i.e., a luminous spot) which move over the display area in response to an input voltage. This luminous spot is produced by a beam of electrons striking on a fluorescent screen. The normal form of the CRO uses a horizontal input voltage which is an internally generated ramp voltage called “time base”.

The horizontal voltage moves the luminous spot periodically in a horizontal direction from left to right over the display area or screen. The vertical voltage is the voltage under investigation. The vertical voltage moves the luminous spot up and down on the screen. When the input voltage moves very fast on the



internally generated ramp voltage called “time base”.

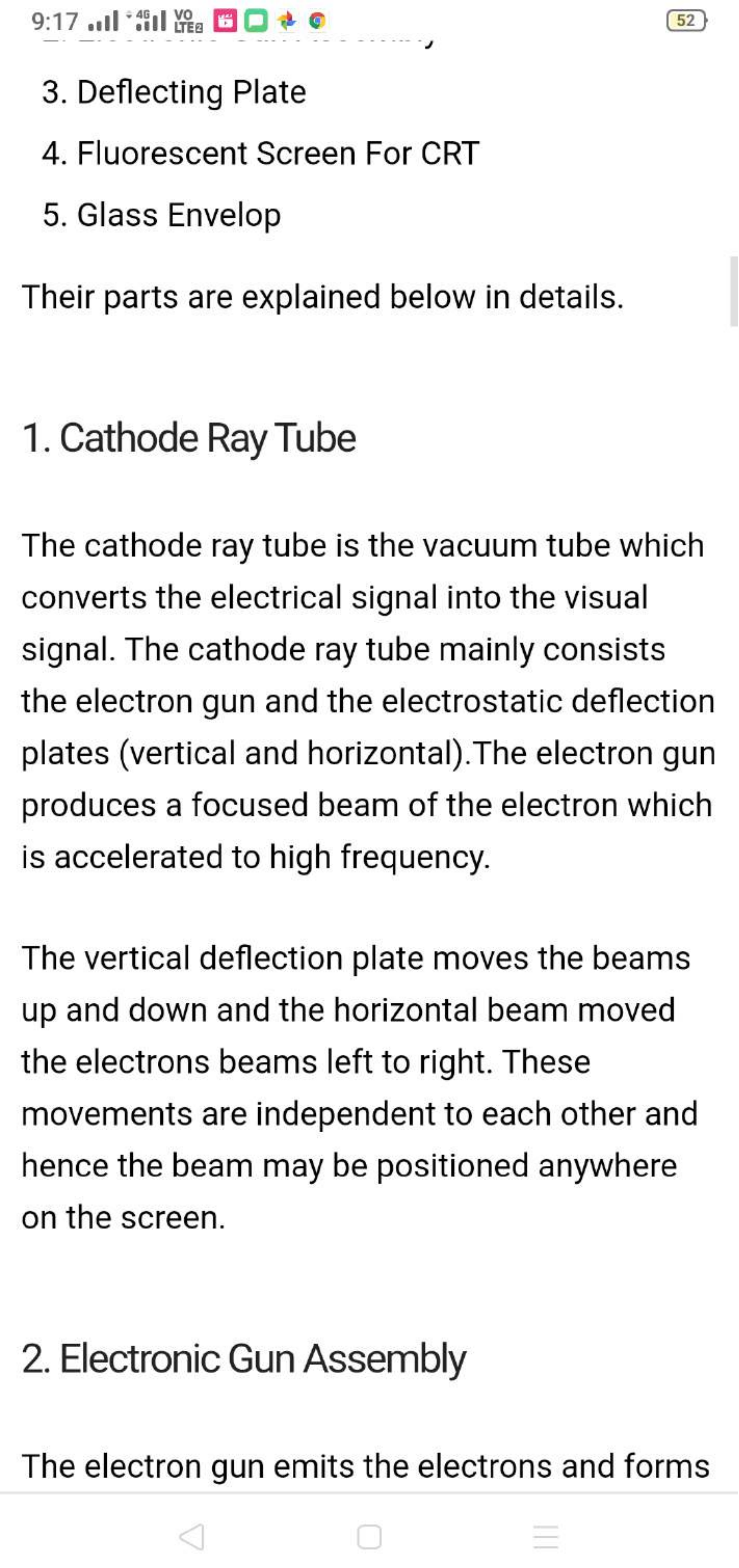
The horizontal voltage moves the luminous spot periodically in a horizontal direction from left to right over the display area or screen. The vertical voltage is the voltage under investigation. The vertical voltage moves the luminous spot up and down on the screen. When the input voltage moves very fast on the screen, the display on the screen appears stationary. Thus, CRO provides a means of the visualising time-varying voltage.

Construction of Cathode Ray Oscilloscope

The main parts of the cathode ray oscilloscope are as follows.

1. Cathode Ray Tube
2. Electronic Gun Assembly
3. Deflecting Plate
4. Fluorescent Screen For CRT
5. Glass Envelop

Their parts are explained below in details



3. Deflecting Plate
4. Fluorescent Screen For CRT
5. Glass Envelop

Their parts are explained below in details.

1. Cathode Ray Tube

The cathode ray tube is the vacuum tube which converts the electrical signal into the visual signal. The cathode ray tube mainly consists the electron gun and the electrostatic deflection plates (vertical and horizontal).The electron gun produces a focused beam of the electron which is accelerated to high frequency.

The vertical deflection plate moves the beams up and down and the horizontal beam moved the electrons beams left to right. These movements are independent to each other and hence the beam may be positioned anywhere on the screen.

2. Electronic Gun Assembly

The electron gun emits the electrons and forms the electrons beams left to right. These movements are independent to each other and hence the beam may be positioned anywhere on the screen.

2. Electronic Gun Assembly

The electron gun emits the electrons and forms them into a beam. The electron gun mainly consists a heater, cathode, a grid, a pre-accelerating anode, a focusing anode and an accelerating anode. For gaining the high emission of electrons at the moderate temperature, the layers of barium and strontium is deposited on the end of the cathode.

After the emission of an electron from the cathode grid, it passes through the control grid. The control grid is usually a nickel cylinder with a centrally located co-axial with the CRT axis. It controls the intensity of the emitted electron from the cathode.

The electron while passing through the control grid is accelerated by a high positive potential which is applied to the pre-accelerating or accelerating nodes.

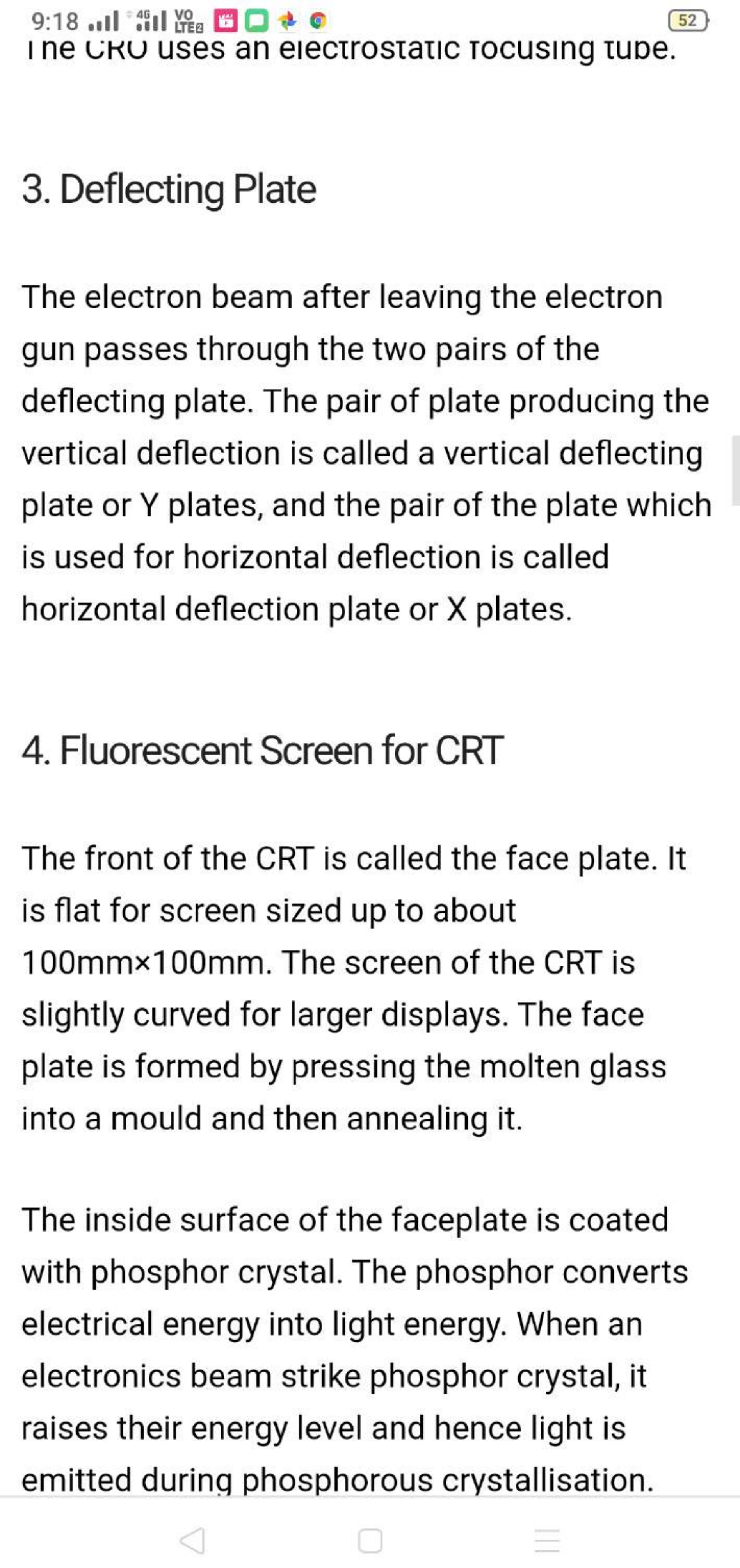
The electron beam is focused on focusing electrodes and then passes through the vertical and horizontal deflection plates and then goes on to the fluorescent lamp. The pre-accelerating and accelerating anode are connected to 1500v, and the focusing electrode is connected to 500 v. There are two methods of focusing on the electron beam. These methods are

- ✓ Electrostatic focusing
- ✓ Electromagnetic focusing.

The CRO uses an electrostatic focusing tube.

3. Deflecting Plate

The electron beam after leaving the electron gun passes through the two pairs of the



The CRO uses an electrostatic focusing tube.

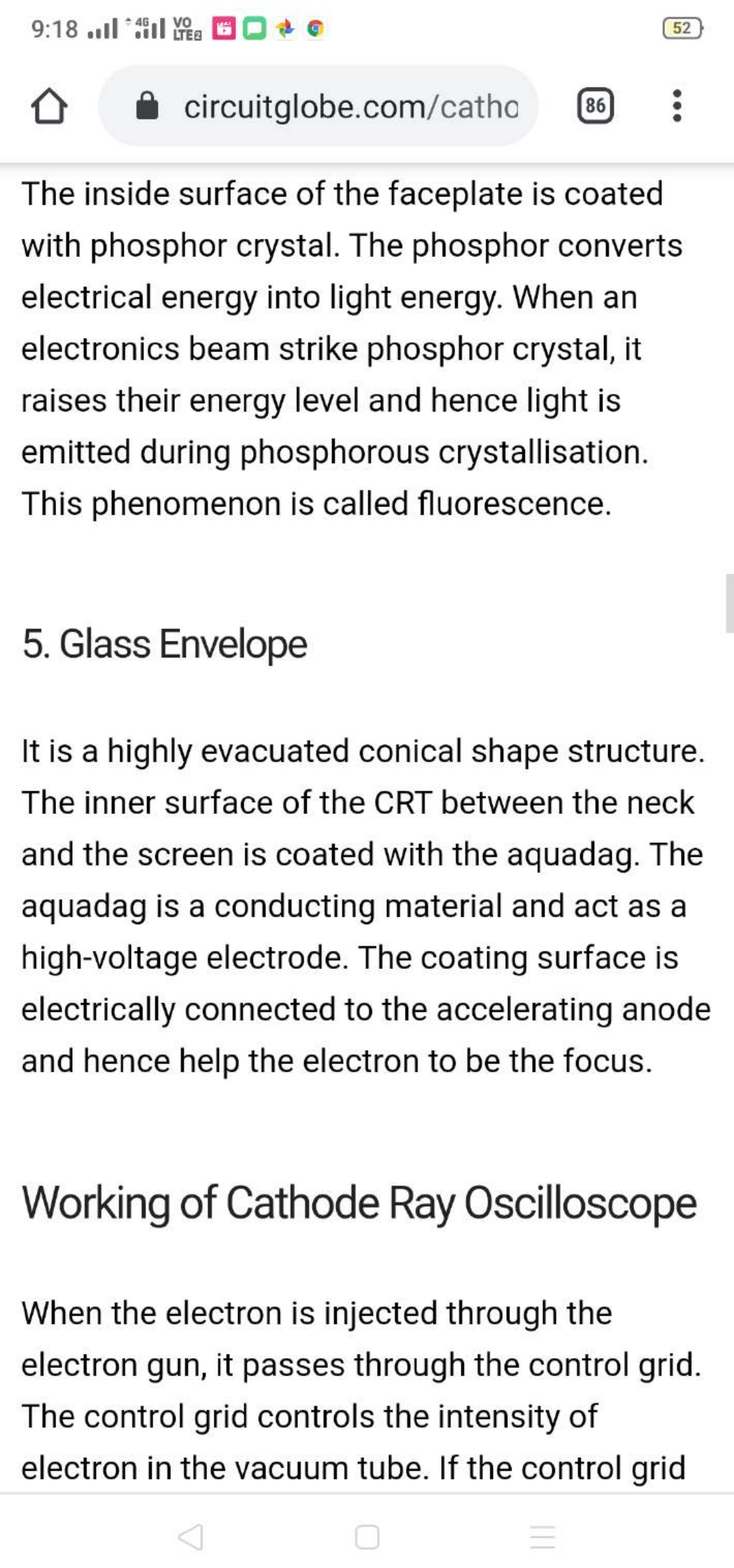
3. Deflecting Plate

The electron beam after leaving the electron gun passes through the two pairs of the deflecting plate. The pair of plate producing the vertical deflection is called a vertical deflecting plate or Y plates, and the pair of the plate which is used for horizontal deflection is called horizontal deflection plate or X plates.

4. Fluorescent Screen for CRT

The front of the CRT is called the face plate. It is flat for screen sized up to about 100mm×100mm. The screen of the CRT is slightly curved for larger displays. The face plate is formed by pressing the molten glass into a mould and then annealing it.

The inside surface of the faceplate is coated with phosphor crystal. The phosphor converts electrical energy into light energy. When an electronics beam strike phosphor crystal, it raises their energy level and hence light is emitted during phosphorous crystallisation.



The inside surface of the faceplate is coated with phosphor crystal. The phosphor converts electrical energy into light energy. When an electronics beam strike phosphor crystal, it raises their energy level and hence light is emitted during phosphorous crystallisation. This phenomenon is called fluorescence.

5. Glass Envelope

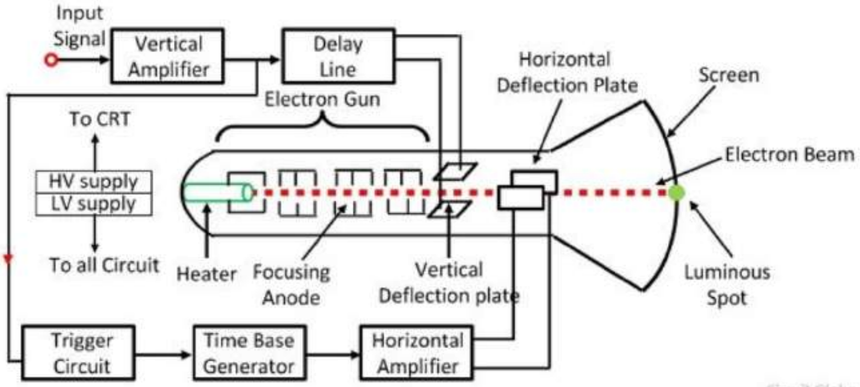
It is a highly evacuated conical shape structure. The inner surface of the CRT between the neck and the screen is coated with the aquadag. The aquadag is a conducting material and act as a high-voltage electrode. The coating surface is electrically connected to the accelerating anode and hence help the electron to be the focus.

Working of Cathode Ray Oscilloscope

When the electron is injected through the electron gun, it passes through the control grid. The control grid controls the intensity of electron in the vacuum tube. If the control grid

Working of Cathode Ray Oscilloscope

When the electron is injected through the electron gun, it passes through the control grid. The control grid controls the intensity of electron in the vacuum tube. If the control grid has high negative potential, then it allows only a few electrons to pass through it. Thus, the dim spot is produced on the lightning screen. If the negative potential on the control grid is low, then the bright spot is produced. Hence the intensity of light depends on the negative potential of the control grid.



Circuit Globe

After moving the control grid the electron beam passing through the focusing and accelerating anodes. The accelerating anodes are at a high positive potential and hence they converge the beam at a point on the screen.

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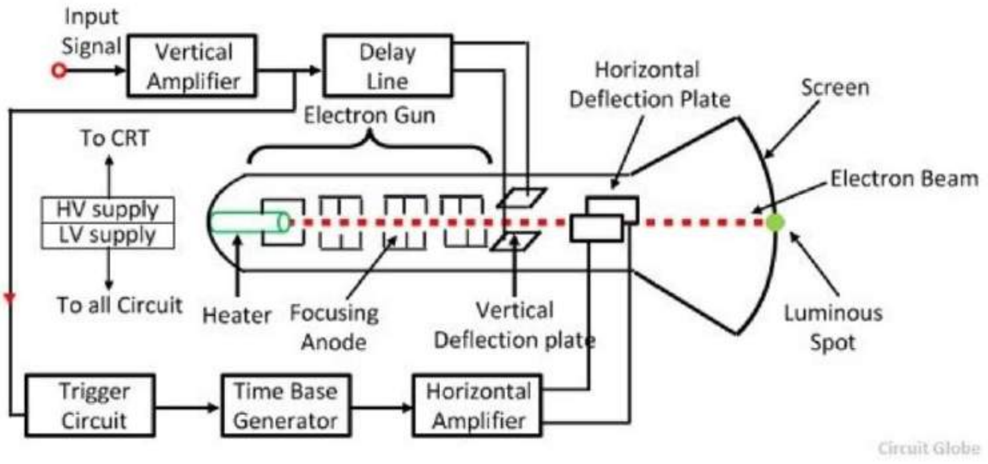

After moving the control grid the electron beam passing through the focusing and accelerating anodes. The accelerating anodes are at a high positive potential and hence they converge the beam at a point on the screen.

After moving from the accelerating anode, the beam comes under the effect of the deflecting plates. When the deflecting plate is at zero potential, the beam produces a spot at the centre.If the voltage is applied to the vertical deflecting plate, the electron beam focuses at the upward and when the voltage is applied horizontally the spot of light will be deflected horizontally.