* AC Voltmeter

The instrument used to measure AC voltage across any two points of electric circuit is called AC Voltmeter. If AC voltmeter consists of rectifier, then it is said to be rectifier based AC voltmeter. The DC voltmeter measures only DC voltages, so if we want to use it for measuring AC voltages, we have to firstly convert AC voltage signal to DC using rectifier & measure DC or average value at rectifier's output signal.

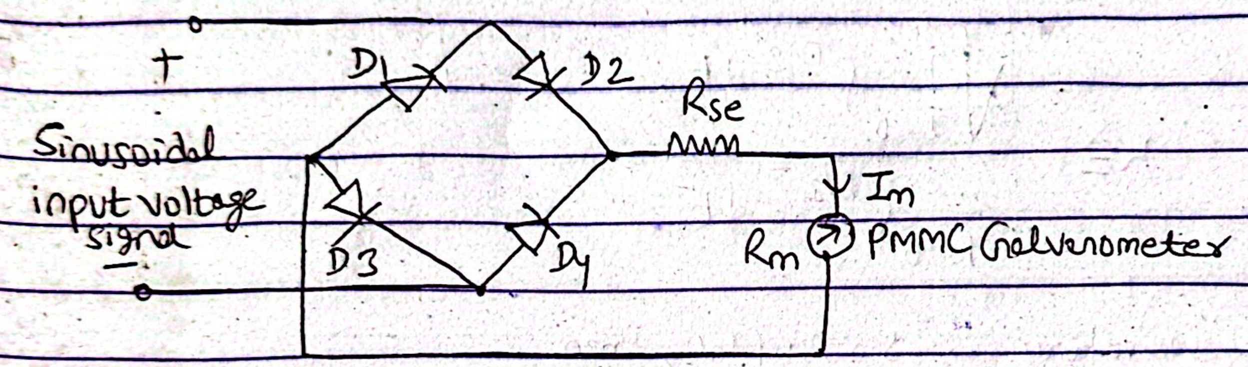

Fig: AC voltmeter using FWR

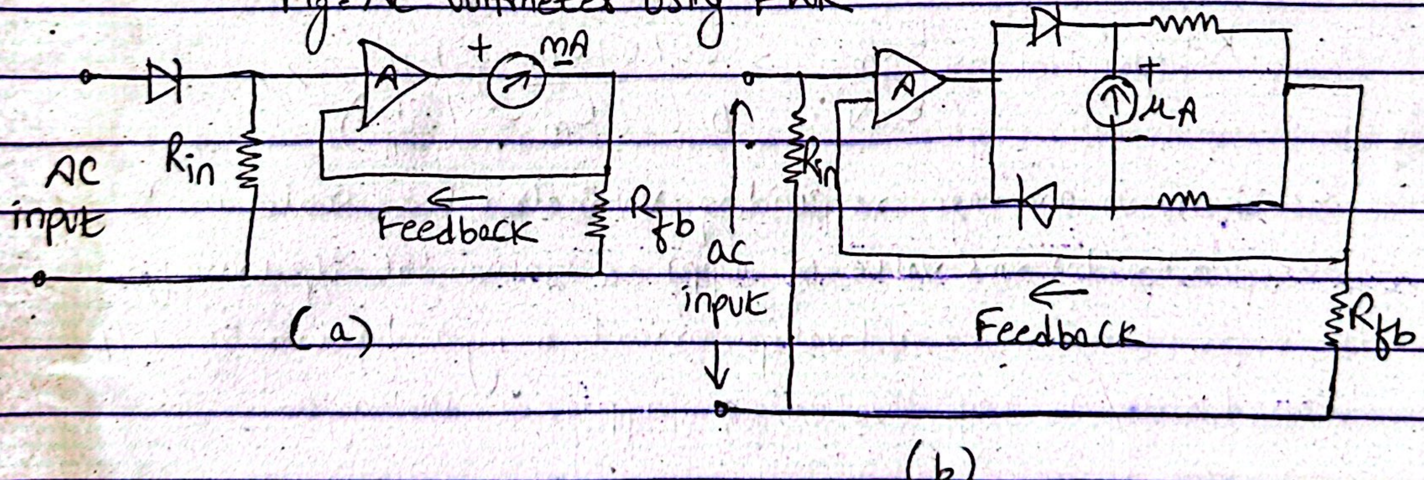

Fig. (a) AC i/p signal is first rectified & then applied to DC amplifier & meter movement

(b) AC i/p signal is first amplified & then applied to FWR in meter circuit

AC voltmeters are usually of average-responding type, with the meter scale calibrated in terms of rms value of sine wave. Since so many waveforms are sinusoidal, this is an entirely satisfactory solution & less expensive than true rms responding voltmeter. Non-sinusoidal waveforms, however, will cause this type of meter to read high or low depending on form factor of waveform. So the form factor, as the ratio of rms value to average value of the waveform, can be expressed as,

$$K = \frac{\sqrt{\frac{1}{T}\int_0^T e^2\,dt}}{\frac{2}{T}\int_0^{T/2} e\,dt}$$

If waveform is sinusoidal, then

$$K_{sinusoidal} = \frac{E_{rms}}{E_{av}} = \frac{0.707E_m \; \left(\frac{E_m}{\sqrt{2}}\right)}{0.636\,E_m \to \left(\frac{2E_m}{\pi}\right)} = 1.11$$

So when an average responding voltmeter has scale markings corresponding to rms value of applied sinusoidal i/p waveform, those markings are actually corrected by a factor of 1.11 from true/average value of applied voltage.

meter. Suppose we have to measure a resistance under

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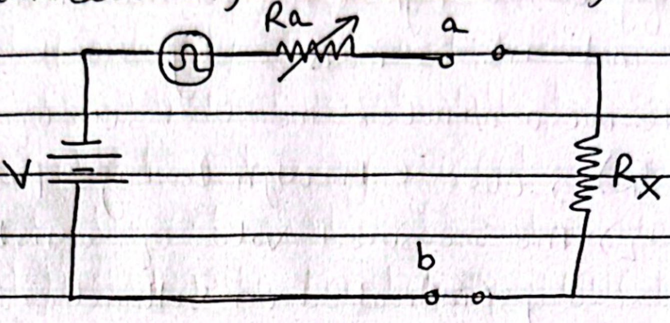
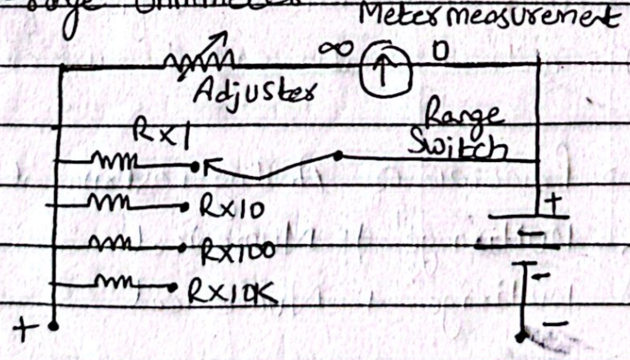
* Ohm Meter & Multirange

The meter which measures the resistance of a material is called an ohmmeter. The micro-ohmmeter is used for measuring low resistance & mega ohmmeter measure high resistance of the circuit. It is of three types:
i) Series Ohmmeter ii) Shunt Ohmmeter iii) Multirange Ohmmeter



The instrument is connected with a battery, a series adjustable resistor, and an instrument that gives reading. The resistance to be measured (R_x) is connected at terminal ab. When the ckt is completed by connecting R_x the ckt current flows & deflection is measured. When the resistance to be measured is very high, then current in ckt will be very small & reading of that instrument is assumed to be max. resistance to be measured.

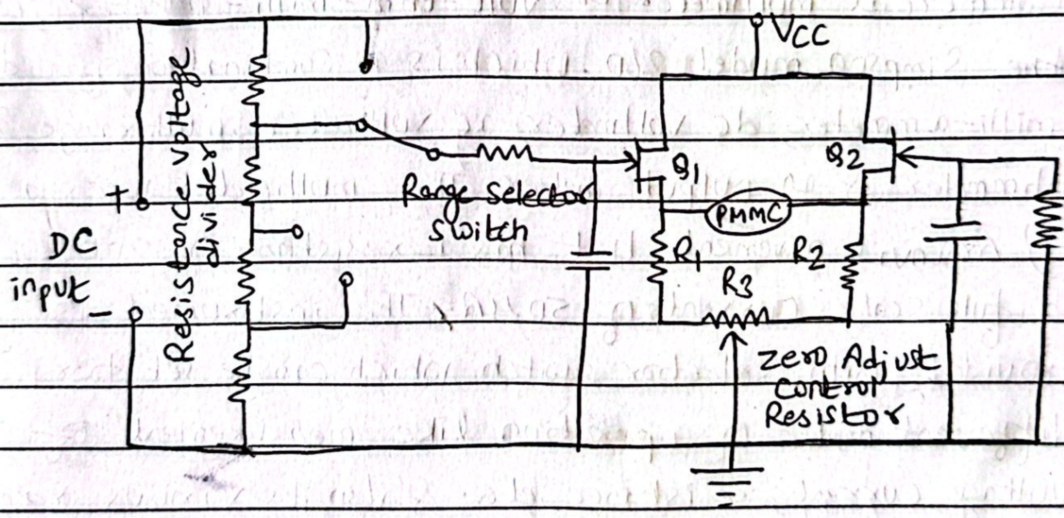
Multi-range Ohmmeter



The range of this ohmmeter is very high. The meter has adjuster which selects range according to need. The resistance to be measured is connected in parallel to the meter. Suppose we have to measure a resistance under 1 ohm then the range switch is selected at 1 ohm range at first. Then that resistance is connected in parallel & corresponding meter deflection is noted. For 1 ohm resistance, it shows full scale deflection but for resistance other than 1 ohm it shows a deflection less than full load value & resistance can be measured.

* Electronic Multimeter

It is a device used for measurement of various electrical & electronic quantities such as current, voltage, resistance etc. It is provided with inbuilt power supply necessary for functioning of device. Any component such as resistor, battery can be connected to its outer probes for measurement of electronic quantity.



The multimeter consists of bridge DC amplifier, rectifier, PMMC meter, function switch, internal battery & an attenuator. The attenuator helps to select particular range of voltage values. Rectifier is used for conversion of AC voltage to DC voltage. The internal battery is needed for operational mechanism of multimeter. The bridge DC amplifier is nothing but two FETs connected opposite to each other with three resistors where R_1 & R_2 are for balancing bridge & R_3 is a zero adjust control resistor.

The multimeter performs its operation by providing i/p voltage to gate terminal of FET & this gate voltage is responsible for increase in source voltage of FET. The PMMC meter is connected between two FET. Ideally, when no i/p is applied no current should flow from PMMC meter, so it must show zero deflection but practically, PMMC meter shows some deflection, so R_z adjusts current value to zero. Now when the input is applied ~~to~~ either by connecting resistor or any other component, the ckt switches to active state & the changes in ckt is deflected with the help of PMMC meter.

* Multimeter or Volt-ohm-milli-ammeter (V.O.M.)

~~The ammeter~~ A representative example of a commercial multimeter or volt-ohm-milli-ammeter is the Simpson model 260 which is a combination of a dc milli-ammeter, dc voltmeter, ac voltmeter, multirange ohmmeter & an output meter. This multimeter uses a D'Arsonval movement that has a resistance of 2000Ω & a full scale current of 50 μA. The instrument is provided with selector switch which can be set for different modes of operation like measurement of voltage, current, resistance, etc. & also its various ranges. The ckt for dc voltmeter section is shown in fig (a) when common input terminals are used for voltage ranges of 0-2.5V to 0-1000V. An external voltage jack marked "DC 5000V" is used for dc voltage measurements upto 5000V. The values of multiplier resistances are given in fig (a). For use on 5000V range the selector switch should be set to 1000V position. The instrument has a sensitivity of 20 kΩ/V which is fairly high. The ckt for measuring dc milliampere & ampere is shown in fig.(b). The common(+) terminal & negative(−) terminals are used for current measurements upto 500mA. The jacks marked +10A & −10A are used for 0−10A range.

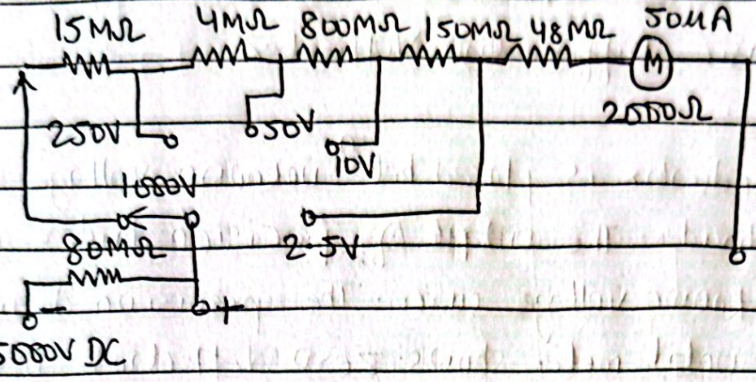


Fig.(a) DC voltmeter section of Simpson Model 260 multimeter

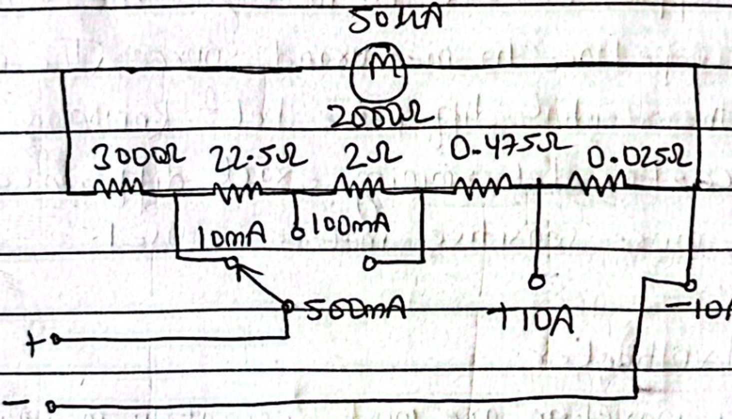


Fig.(b) Ammeter section of Simpson model 260 multimeter

* Differential Voltmeter

The voltmeter which measures difference between known & unknown voltage source is known as differential voltmeter. It works on the principle of comparison between reference & unknown voltage sources. The accuracy of differential voltmeter is very high. The principle of operation of differential voltmeter is similar to that of potentiometer & hence it is called potentiometer voltmeter.

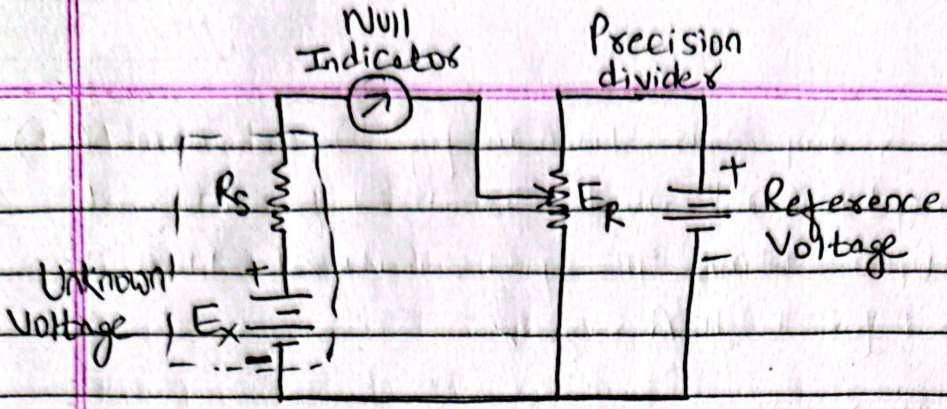


Fig: Basic Differential Voltmeter

The null indicator is placed betn unknown voltage source & precision divider. The output of precision divider is connected to known voltage source. The precision divider is adjusted until meter shows zero deflection. The null deflection of indicator/meter shows that magnitude of both known & unknown voltage source becomes equal, & neither of the source applies current to meter, & the voltmeter shows high impedance to measurand source. The null meter only shows the residual difference betn known & unknown voltage source, For determining exact difference betn the sources, more sensitive meter is used.

* True RMS voltmeter

Complex waveform are most accurately measured with an rms voltmeter. This instrument produces a meter indication by sensing waveform heating power which is proportional to square of rms value of voltage. This heating power can be measured by amplifying & feeding it to a thermocouple whose output voltages is then proportional to E_{rms}. The effect of non-Linear behaviour of thermocouple in the input circuit (measuring thermocouple) is cancelled by similar non-linear effects of the thermocouple in the feedback circuit (balancing thermocouple). The two couples form part of a bridge in the input circuit of a dc amplifier. The unknown ac voltage is amplified & applied to heating element of measuring thermocouple. The application of heat produces an output voltage that upsets the balance of the bridge. The dc amplifier amplifies unbalanced voltage. This voltage is feedback to heating element of balancing thermocouple which heats the thermocouple so that the bridge is balanced again ie the outputs of both the thermocouples are same. At this instant, the ac current in the input thermocouple is equal to dc current in heating element of feedback thermocouple. This dc current is therefore directly proportional to effective or rms value of i/p voltage & is indicated by meter in o/p ckt of dc amplifier. If the peak amplitude of ac signal does not exceed dynamic range of ac amplifier, the true rms value of ac signal can be measured independently.

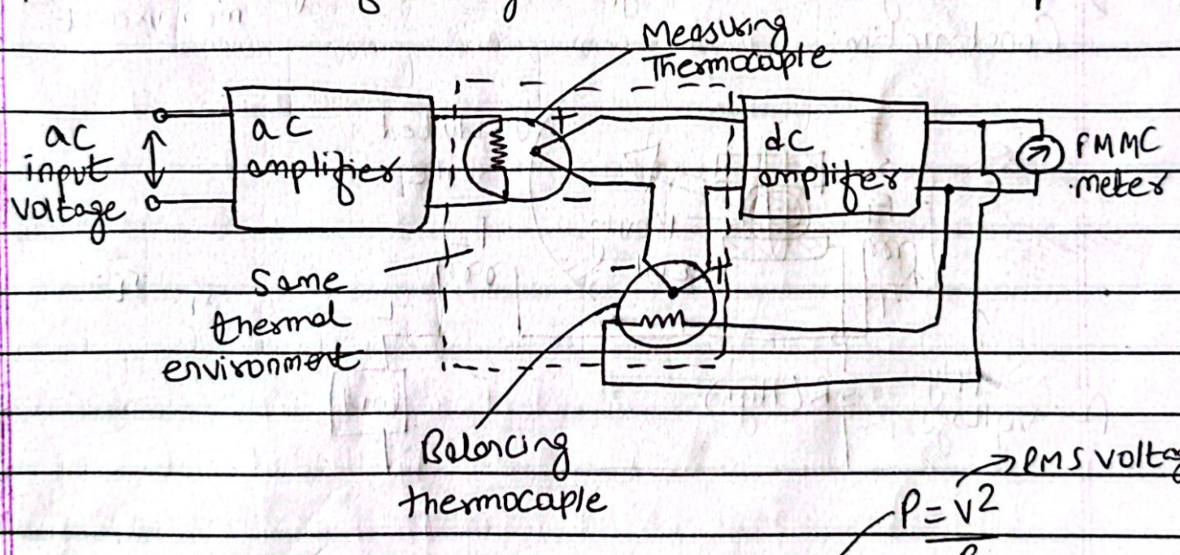


Fig: True RMS voltmeter

$P = \frac{V^2}{R}$ → RMS voltage

Balancing & measuring thermocouple are in series but in opposition

→ imbalance हुनेको 2 वटा thermocouple ले different op दिनेले

Thermocouple मा heating element को energy

$E \propto P \propto V^2$

कति आएको छ — Sq. of rms voltage

So heating element ले voltage produce गर्छ

DC amplifier को i/p is difference of o/p of 2 thermocouples. So 2 thermo-

$$P = \frac{E}{t} = \frac{VIt}{t} = VI.$$

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* Wattmeter → industrial area मा mainly used.

A wattmeter is essentially an inherent combination of ammeter & voltmeter & therefore consists of two coils known as current coil & pressure coil (voltage coil). The general connection of wattmeter for single phase wattage (power measurement) is shown in fig. below.

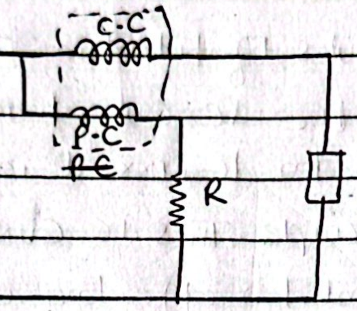
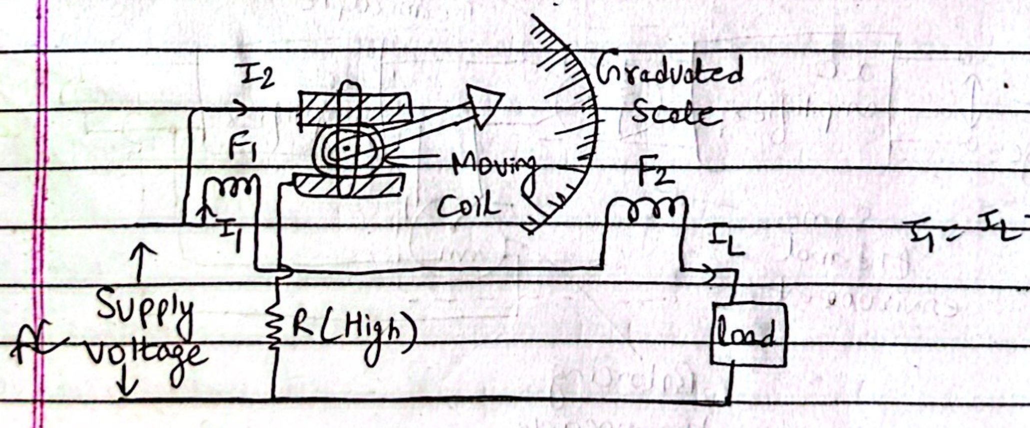


Fig: 1-ϕ wattmeter connection

Types of Wattmeter:

i) Electrodynamometer Type Wattmeter - for both DC & AC power measurement

Construction:



It consists of two coils: fixed coil & moving coil. The fixed coil is divided into two halves: F_1 & F_2, which are connected in series with load whose power is to be measured. The moving coil is connected to the supply voltage in parallel. A high resistance 'R' is connected in series with moving coil as moving coil is → to limit current through

→series with load   or series or fixed coil.
Fixed coil also called current coil
Moving " " " potential " or pressure coil.
└ parallel with load

connected across the supply voltage.

Working Principle: (Induction type में है)

Mathematical derivation:

In case of dynamometer type Wattmeter, there is no iron core so field strength & hence flux density is directly proportional to current 'I_1' & is given by,

$$B = KI_1 \quad -(i)$$

So the fixed coils 'F_1' and 'F_2' are responsible for producing required magnetic field. Now when the current flows through the moving coil, it experiences deflecting torque & moves to show deflection. The deflecting torque produced is given by,

because moving coil का field lines to come in line with fixed coil का field.

$$\tau_d = BI_2 \quad -(ii)$$

Since $I_2 = KV$ & $B = KI_1$ → becoz moving coil is in parallel with load so I_2 current is proportional to voltage across the load.

$$\tau_d \propto KVI_1$$

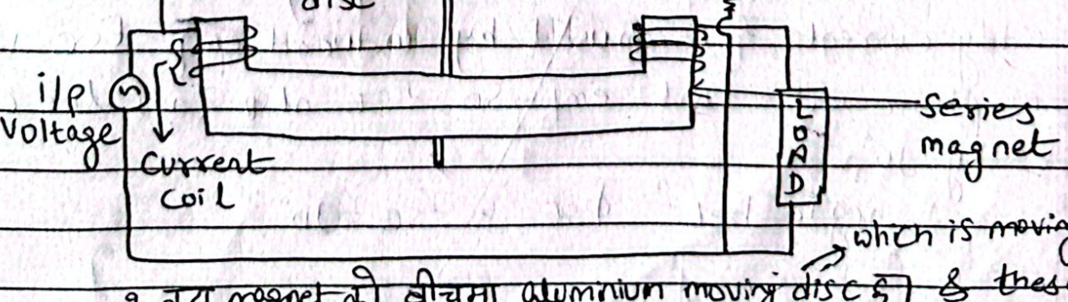
$$\tau_d = K \cdot \text{power} \rightarrow \text{for dc}$$

For ac $\tau_d = Vi$ $V \rightarrow rms$, $i \rightarrow rms$

$$P = Vi\cos\phi$$

ii) Induction type Wattmeter - for AC power measurement only

Construction:



Shunt magnet का potential coil का binding & series magnet का current coil का।

2 वटा magnet को बीचमा aluminium moving disc छ which is moving part & these two magnets & disc are connected with spindle. जब दायाँ current दिन्छ, series magnet मा magnetic flux or alternating flux generate हुन्छ which produces eddy current in Alu-