



## Electrical instruments and measurements

### Electrical principles of operation :

All electrical measuring instruments depend for their action on one of the many physical effects of an electrical current or voltage and are generally classified according to which of these effects is utilized in their operation .

1. Magnetic effect , used for ammeters and voltmeters .
2. Electrodynamics effect , used for ammeters ,voltmeters and wattmeter.
3. Electromagnetic effect , used for ammeters ,voltmeters , wattmeter and watt – hour meters .

### Indicating instruments :

Indicating instruments are those which indicate the value of the quantity that is being measured at the time at which it is measured . Such instruments consist of a pointer which moves over a calibrated scale and which is attached to a moving system .

The moving system is subjected to the following three torques :

- i) A deflecting ( or operating ) torque .
- ii) A controlling ( or restoring ) torque .
- iii) A damping torque .



**i. Deflecting Torque :**

The deflecting torque is produced by utilizing one of the physical effects mentioned before , ( magnetic , electrostatics or electromagnetic effect ).

The deflecting torque causes the moving system to move from zero position to another position .

**ii. Controlling torque :**

This torque opposes the deflecting torque and increases with the deflection of the moving system . The pointer is brought to rest at apposition where the two opposing torques are equal .

In the absence of a controlling torque , the pointer would not return to zero position . The controlling torque is obtained by a spring or by gravity .

**iii. Damping torque :**

A damping force is one which acts on the moving system only when it is moving and always opposes its motion . This force is necessary to bring the pointer to rest quickly , otherwise due to inertia of moving system , the pointer will oscillate about its final deflected position for some time

The damping force can be produced by :

- i) Air friction .**
- ii) Eddy currents .**
- iii) Fluid friction .**



## Ammeter And Voltmeter

### 1. Moving – iron type :

Used for both A.C and D.C measurements . The operation of this type depends on the attraction of a single piece of soft iron into magnetic field .

The necessary magnetic field is produced by ampere turns of a current – carrying coil . In case of ammeter , the coil has a few turns of thick wire so that the ammeter has low resistance because it is connected in series with the circuit In case of voltmeter , the coil has high resistance ( it has large number of turns of thin wire ) . It is connected in parallel with the circuit .

### Advantages and disadvantages :

The advantages of this type are , such instruments are cheap and robust , give reliable service and can be used for A.C and D.C circuits The disadvantage of this type is that , because of hysteresis in the iron paths of the moving system the readings are higher for descending values but lower for ascending values .

### 1. Moving – coil type :

There are two types of such instruments :

- i) Permanent – magnet type .
- ii) Dynamometer type .

### Permanent – Magnet Type :

This type is used for D.C circuit only . The operation of this type is based upon the principle that when a current – carrying conductor is placed in a magnetic field , it is acted upon by a force which tends to move it to one side and out of the field . it consist of a permanent magnet and rectangular coil of many turns wound on a light aluminum or copper former inside .



### Advantages :

1. Their scales are uniform and can be designed to extent over an arc of 270o .
2. They can be modified with the help of shunt resistance to cover a wide range of current and voltage .
3. They have no hystercics loss .

### Disadvantages :

1. The cost is higher than that of moving – iron type .
2. This type used for D.C circuit only .
3. It has some errors because of permanent magnet .

### Dynamometer type:

This type is used A.C and D.C circuits . In this type the operation field is produced , not by a permanent magnet but by another fixed coil . This instrument can be used either . as ammeter or as voltmeter

The fixed coils are usually arranged in two equal sections placed close together and parallel to each other . The two fixed coils are air – cored to avoid hystercics effect . This make the magnetic field in which the moving coil , more uniform . Such instruments are . free from hystercics error

## Ohmmeter

For constant voltage , the current through the meter will vary if the resistance varies . An ohmmeter is always constructed by a set of fixed swichable resistances and a battery that provides a known constant voltage By selecting the resistances , the meter will give indications in ohms over any desired range .



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Usually zero on the meter is assigned the value of infinity ohms . The full – scale value is set at a certain minimum . It is necessary that the battery be exactly the right kind and provides appropriate voltage .

### Induction wattmeter :

This type is used on A.C circuit only , while the dynamometer wattmeter can be used both on A.C and D.C circuits .

Induction wattmeter is useful only when the frequency and supply voltage are constant . The wattmeter has two laminated electromagnets , one of which is excited by the current in the main circuit , its windings being joined in series with the circuit . The other is excited by current which is proportional to the voltage of the circuit Its windings being joined in parallel with the circuit . A thin aluminum disc is so mounted that it cuts the fluxes of both magnets.

Hence two eddy currents are produced in the disc . The deflection torque is produced due to interaction of these eddy currents and the inducting flux.