Reading instrument scales

Objectives: At the end of this lesson you shall be able to
- **distinguish the class of instruments based on measuring accuracy**
- **state the different types of scale graduations**
- **state the sources of error when measuring**
- **state the precautions to be used while using instruments.**

All measurements must be as accurate as possible and must have the smallest possible influence on the system. To ensure that the influence on the system is reduced as much as possible, particular care must be taken in selecting the correct measuring instrument and in employing the correct method of making measurements.

When selecting a measuring device, care should be taken that the measured value is indicated on the scale above 60% of the full scale value. This reduces the measuring error as much as possible.

Classification of instrument as per accuracy: The classification of measuring devices is based on the measuring accuracy and is dependent on the quality and the application. Measuring instruments are divided into quality classes as follows.

Class	Application
0.1 0.2 0.3	Precision and laboratory measuring devices
0.5	Portable measuring devices and laboratory devices
1.0 1.5 2.5	Industrial and panel measuring devices

The indicated number under the column `class' represents the relative error.

Example: Quality class 1.5 refers to a relative measuring error of ±1.5% which means that the indicated error may be ±1.5% of the rated value.

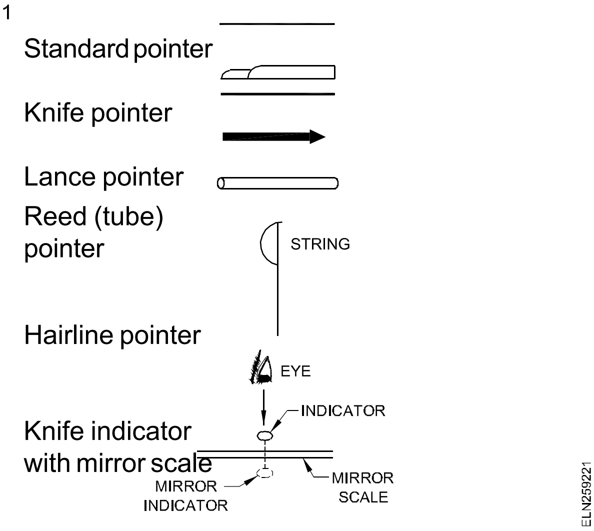
Reading accuracy: The reading accuracy of a measuring device must always be greater than the measuring accuracy. By the application of the correct indicator arrangement, the reading accuracy may be increased.

The indicator arrangement, that is discussed is for an indicator (pointer) with a scale.

Indicators (Pointers): Indication of readings is obtained by the mechanical movement of a pointer which moves parallel to the divisions of the scale.

Following are the different types of pointers used in instruments (Fig 1).

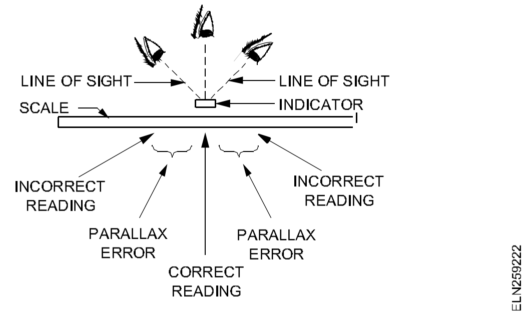
Fig 1



Due to the gap between the pointer and the scale, while reading an instrument, a slanting view may be obtained. Depending on the eye angle, a reading error may exist. This error is known as parallax error.

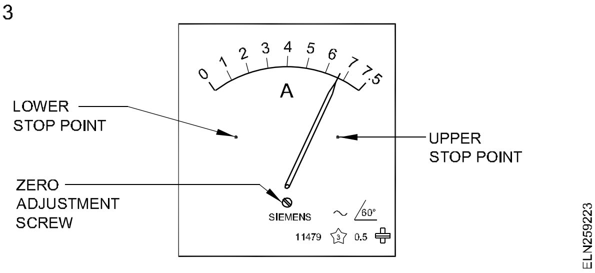
Mirror scales: Mirror scales are used in precision devices and Industrial devices of higher quality class. When reading, the indicator must cover its image (picture) in the mirror, so as to avoid reading errors caused by reading the scale from an angle (parallax error) (Fig 2).

Fig 2



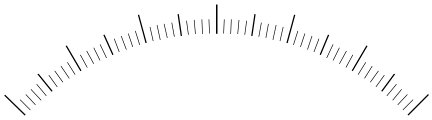
Zero adjustment: The mechanical zero of the pointer may be adjusted by an external screw adjustment (Fig 3).

Fig 3

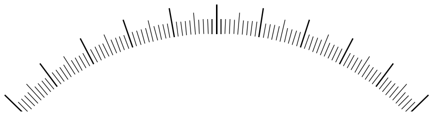


Types of scales

1 **Coarse and coarse-fine scale:** Coarse scales and coarse-fine scales are used primarily in panel instruments with a quality class from 1 to 2.5.



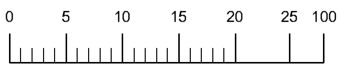
COARSE-FINE DIVISION



2 **Fine scale**: Performance for precision and laboratory devices with a quality class from 0.1 to 0.3 are used mostly in conjunction with a mirror scale.

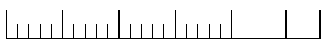
STANDARD WORKS DIVISION
FINE DIVISION

3 **Extended scale**: Used primarily for current measurements with short overload time i.e. starting current of motors.



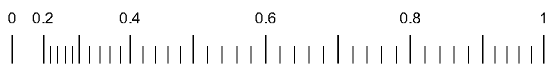
EXTENDED SCALE

4 **Linear scales**: Linear scales are used primarily in moving coil measuring devices. The graduations are uniform throughout the span.



EXTENDED SCALE

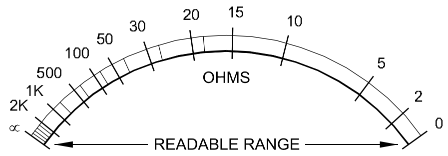
5 **Non-linear scales:** Non-linear scales are used primarily in moving iron measuring devices. The graduations on the scale are not uniform. They are crowded in the begining of the scale



Non-linear scales, coarse: The dot under the division mark indicates the start and end of the measuring range. This instrument should not be used for measurement of value below the start range.

The ohmmeter scale is also non-linear. It may be noted that the zero on the scale is on the right hand side. (Fig 4)

Fig 4



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Sources of errors when measuring

1 **Device errors**: This error will occur as a result of careless assembly, damage, false adjustment or when used in a false position. While using the instrument it must be used in the position as specified on the dial.

2 **Influence errors**: These are errors caused by the effect of environment, such as humidity (dampness), temperature, vibrations, electrical or magnetic fields.

3 **Switching errors**: These errors are caused by the influence of the electrical quantity being measured, through incorrect method of connection before measurement or false selection of the proper measuring device.

4 **Human errors:** Reading errors caused by looking at the indicator (pointer) from an angle (parallax error) or false reading of middle value of subdivision graduation.

Reading the scales: When using a multi-range ammeter or voltmeter, it is important to know the function of the range switch. The range switch selects the amount of current or voltage that causes full-scale deflection (FSD) of the meter. When measuring an unknown quantity, it is wise to start out on the highest range and reduce to a lower range until you get a deflection somewhere between mid and full scale if possible.

To avoid placing as many scales on the meter as there are ranges, some scales are used for many different ranges simply by multiplying or dividing the scale numbers by 10 or 100. For instance, to read a multi-range meter, find the range being used on the range switch and determine which scale has a full-scale deflection most closely corresponding to the range. Then read off the number from the scale where the pointer has come to rest.

The following examples illustrate the method.

Example 1 (Fig 5)

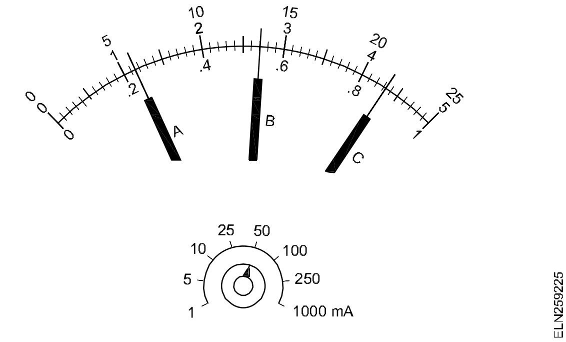
Multi-range DC milliammeter scale with range switch on 50mA.

At A: Reading is between 10 and 20 i.e. = 11.5mA.

At B: Reading is between 20 and 30 i.e. = 27mA.

At C: Reading is between 40 and 50 i.e. = 43.5mA.

Fig 5



Multi-range AC/DC voltmeter scales with range and function switches set to 5V DC.

Example 2 (Fig 6): With the range switch on 5V DC, the FSD must be 5V on the AC/DC scale. Therefore, we must use the 0-50 scale with each number divided by 10.

At A: Reading is between 0.5 and 1.0 i.e. = 0.72V.

At B: Reading is between 2.0 and 2.5 i.e. = 2.37V.

At C: Reading is between 4.0 and 4.5 i.e. = 4.30V

Example 3 (Fig 6): With the range switch on 150V AC, the FSD must be 150V on the AC/DC scale. Therefore, we must use the 0-15 scale with each number multiplied by 10.

At A: Reading is between 20 and 30 i.e. = 23V.

At B: Reading is between 70 and 80 i.e. = 75V.

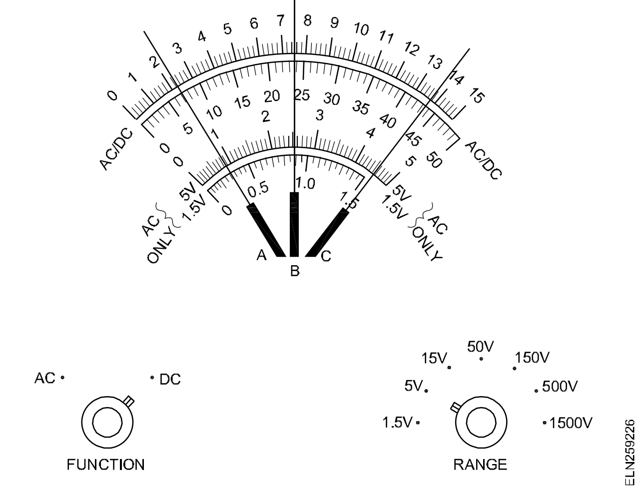
At C: Reading is between 130 and 140 i.e. = 136V.

Precautions to be observed while using an instrument

1 Select the meter for the electrical quantity to be measured, eg. voltage, current, resistance.

2 Choose the correct range for the quantity being measured, eg. for measuring 10V the correct range is 0-15V.

Fig 6



3 Identify the correct instrument suitable for AC/DC measurements.

4 Use the instrument in the correct position as specified.

5 Ensure correct polarity while connecting MC type instrument.

6 Errors are caused by the effect of the environment, such as humidity (dampness), temperature, vibrations, electrical or magnetic fields. Care should be taken to avoid such environmental factors.

7 Read the instrument looking straight at the pointer to avoid parallax error.

8 In mirror back scale read such that the pointer coincides with its image in the mirror.

9 If there is any zero error this must be corrected before using the instrument by the zero adjustment screw.

Classification of electrical instruments - Essential forces, MC and MI meter

Objectives: At the end of this lesson you shall be able to

- **classify electrical instruments with respect to standard, function and operation by the effect of electric current**
- **explain the type of forces required for the proper functioning of an electrical indicating instrument.**

Electrical instruments may be classified based on the following.

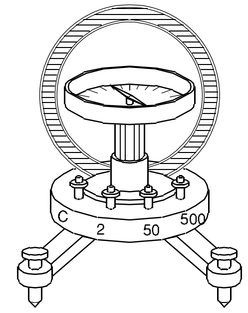
- Manufacturing standards
- Function
- Effects of electric current on the instruments.

Manufacturing standards: The electrical instruments may, in a broad sense, be classified according to the manufacturing standards into absolute instruments and secondary instruments.

Absolute instruments: These instruments give the value of quantity to be measured in terms of deflection and instrument constants. A good example of an absolute instrument is the tangent galvanometer (Fig 1).

In this instrument the value of current could be calculated from the tangent of the deflection produced by the current, the radius and number of turns of wire used and the horizontal component of the earth's magnetic field. No previous calibration or comparison is necessary in this type of instruments. These instruments are used only in standard laboratories.

Fig 1



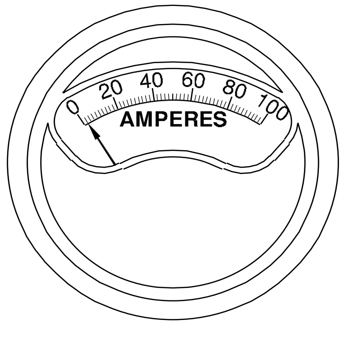
Secondary instruments: In these instruments the value of electrical quantity (voltage, current, power, etc.) to be measured can be determined from the deflection of the instruments on the calibrated dial. These instruments should be calibrated in comparision with either an absolute instrument or with one which has already been caliberated. All the instruments used commercially are secondary instruments.

Functions

Secondary instruments are further classified according to their functions, that is, whether the instrument indicates, or records the quantity to be measured. Accordingly, we have indicating, integrating and recording instruments.

Indicating instruments: These instruments (Figs 2) indicate the value of voltage, current power etc., directly on a graduated dial. Ammeters, voltmeters and wattmeters belong to this class.

Fig 2



Integrating instruments: These instruments measure the total amount, either the quantity of electricity or the electrical energy, supplied to a circuit over a period of time. Ampere hour meters and energy meters belong to this class. Fig 3 shows the Kilowatt hour/energy meter.

Recording instruments: These instruments register the quantity to be measured in a given time, and are provided with a pen which moves over a graph paper. With this instrument, the quantity can be checked for any particular date and time. Recording voltmeters,ammeters and power factor meters belong to this class. Fig 4 shows such a recording instrument.

Effects of electric current used on electrical instruments: Secondary instruments may also be classified

Fig 3

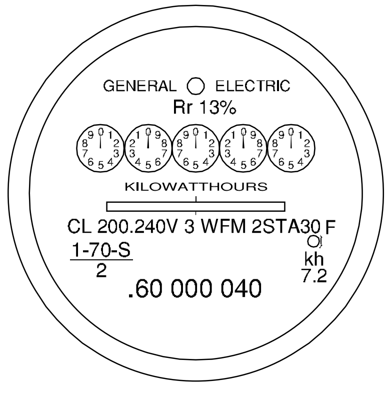
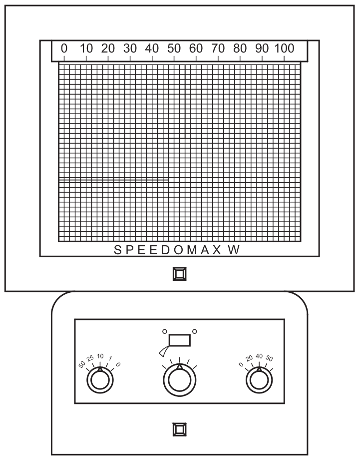


Fig 4



according to the various effects of electricity upon which their operation depends. The effects utilised are as follows.

- Magnetic effect
- Heating effect
- Chemical effect
- Electrostatic effect
- Electromagnetic induction effect

Essential forces required for an indicating instrument: The following three forces are essential requirements of an indicating instrument for its satisfactory operation. They are

- deflecting force
- controlling force
- damping force.

Deflecting force or operating force: This causes the moving system of the instrument to move from its `zero' position, when the instrument is connected to the supply. To obtain this force in an instrument, different effects of electric current, such as magnetic effect, heating effect, chemical effect etc. are employed.

How this deflecting force is developed in an instrument will be explained later while explaining the individual type of instruments.

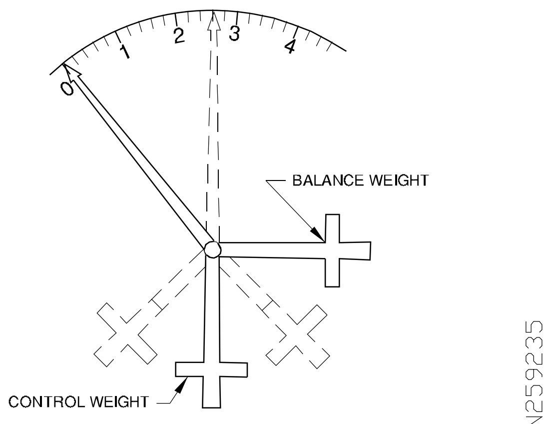
Controlling force: This force is essential to control the movement of the moving system and to ensure that the magnitude of the deflction of the pointer is always the same for a given value of the quantity to be measured. As such, the controlling force always acts opposite to the deflecting force, and also brings the pointer to zero position when the instrument is disconnected from the supply.

The controlling force could be produced by any one of the following ways.

- Gravity control
- Spring control

Gravity control: In this method, small adjustable weights are attached to the opposite extension of the pointer (Fig 5). These weights are attracted by the earth's gravitational pull, and thereby, produce the required controlling force(torque). The instruments with gravity control are to be used in the vertical position only.

Fig 5



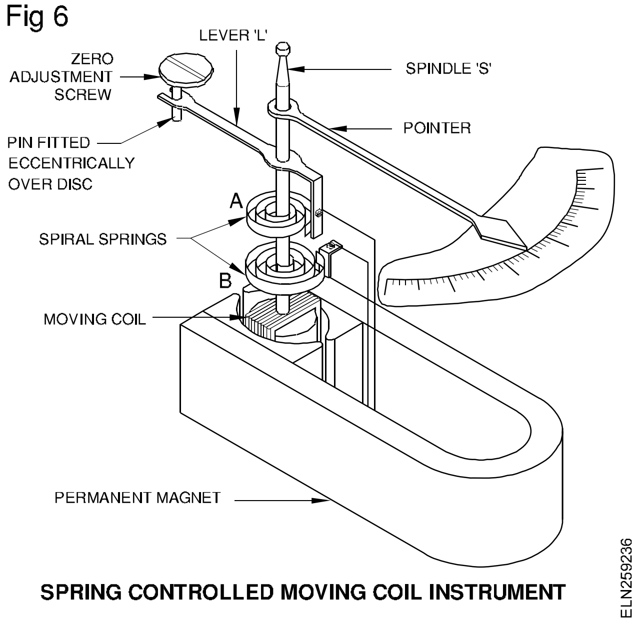
GRAVITY CONTROL

When the instrument is not connected to the supply, the control weight and the balance weight attached to the opposite end of the pointer make the pointer to be at zero position (Fig 5). When the instrument is connected to the supply, the pointer moves in a clockwise direction, thereby displacing the weights (Fig 5). Due to the gravitational pull, the weights will try to come to their original vertical position, thereby exerting a controlling force on the movement of the moving system.

Spring control: The most common arrangement of spring control utilises two phosphor-bronze or beryllium-copper spiral hair-springs A and B, the inner ends of which are attached to the spindle S (Fig 6). The outer end of the spring B is fixed, whereas that of A is attached to the end of a lever `L' pivoted at P, thereby enabling the zero adjustment to be easily effected when needed.

The two springs A and B are wound in opposite directions so that when the moving system is deflected, one spring winds up while the other unwinds, and the controlling force is due to the combined torsions of the springs.

Fig 6



SPRING CONTROLLED MOVING COIL INSTRUMENT

These springs are made from such alloys that they have:

- high resistance to fatigue (can be wound or unwound several times without loosing the tension)
- non-magnetic properties (should not get affected by external magnetism)
- low temperature cofficient (do not elongate due to temperature)
- low specific resistance (can be used for leading current `in' and `out' of the moving system).

Spring controlled instruments have the following advantages over the gravity controlled instruments.

They are:

- the instruments can be used in any position
- the control springs help in leading in and out the current to the moving coil of the instruments.

Damping force: This force is necessary to bring the moving system to rest in its final deflected position quickly.Without such damping, the combination of the inertia of the moving system and the controlling force makes the pointer (moving system) to oscillate about its final deflected position for some time before coming to rest, resulting in a waste of time in taking the reading.

Critical/under/over damping: If the pointer moves quickly to its final deflected position without any sort of oscillation, the damping is called as 'critical damping' and the instrument is the 'dead beat'.

On the other hand in the under-damped instrument, the pointer will oscillate before coming to the final deflected position, and in the case of an over-damped instrument, the pointer comes slowly to the final deflected position.

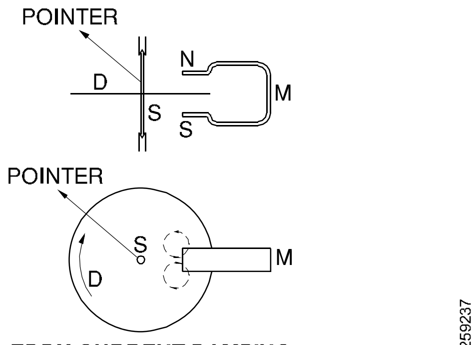
The two methods of damping, commonly employed are:

- eddy current damping
- air friction damping.

Eddy current damping: Fig 7 shows one form of eddy current damping. A copper or aluminium disc D,is attached tothe spindle 'S'. When the pointer moves, the disc also moves.

The disc is made to move in the air gap between the poles of a permanent magnet M. The moving disc cuts the flux, thereby inducing eddy currents in the disc. According to Lenz's law, the flux produced by the eddy current opposes the movement of the disc, thereby effecting the damping force.

Fig 7

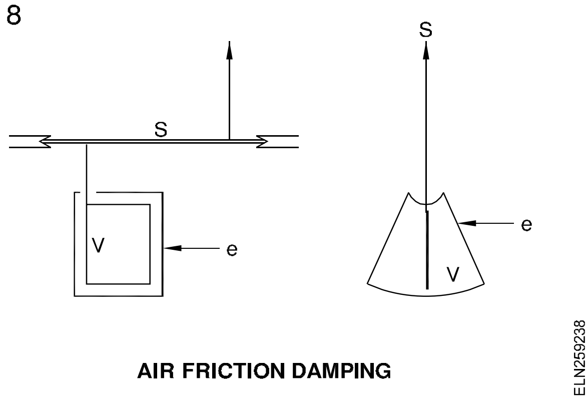


EDDY CURRENT DAMPING

In the case of moving coil instruments, the moving coil is wound on a thin aluminium former. The eddy currents induced in the former produces the damping force.

Air friction damping: Fig 8 shows the method of obtaining air friction damping. Accordingly a thin metal vane V is attached to the spindle S, and the vane is made to move inside a sector shaped box 'e' while the pointer moves on the graduated scale.

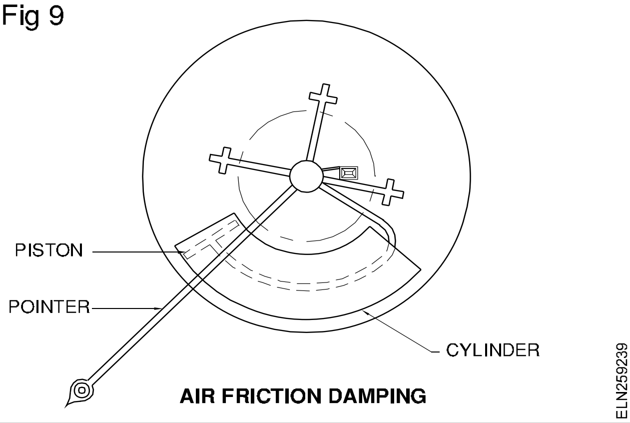
Fig 8



AIR FRICTION DAMPING

Alternatively, the vane in the form of a piston could be arranged to move inside an air chamber (cylinder) as shown in Fig 9. In the above two cases, the air inside the air chamber opposes the movement of the vane/piston, and, thereby, the damping force is created.

Fig 9



AIR FRICTION DAMPING

Permanent magnet moving coil (PMMC) instruments

Objectives: At the end of this lesson you shall be able to
- **state the principle of a permanent magnet moving coil (P.M.M.C) instrument**
- **describe the construction and operation of a P.M.M.C instrument**
- **state the uses, advantages and disadvantages of a P.M.M.C instrument.**

Moving Coil and Moving Iron Instruments :

Instruments are classified based on their moving system They are :

(i) Moving Coil Instruments (MC)

Permanent Magnet Moving Coil Instrument (PMMC)
Dynamo meter type instruments

(ii) Moving Iron Instruments (MI)

Attraction type
Repulsion type

Permanent magnet moving coil (PMMC) instruments

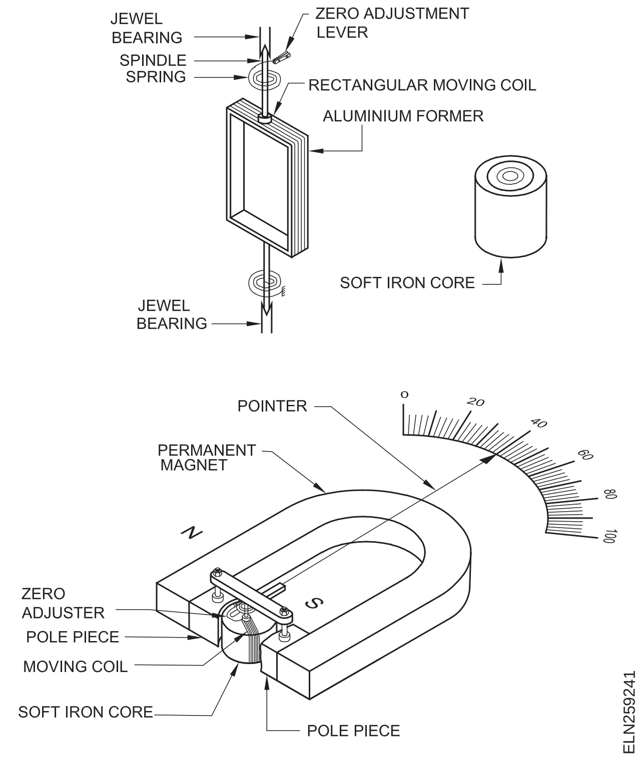
The most commonly used instrument to measure DC quantities like voltage and current, is the permanent magnet moving coil (PMMC) instrument.

Principle: The working of the PMMC instrument is based on 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 the conductor. The DC motor also works on this principle.

Construction: The PMMC instrument consists of a permanent magnet and a rectangular coil wound with a very fine gauge insulated copper wire on a thin light aluminium former.

The aluminium former not only supports the coil, but also produces eddy current for damping. The coil and the former are attached with spindles on either side, and supported by jewelled bearings so as to make the assembly move freely in the air gap (Fig 1).

Fig 1



The two ends of the coil are connected to two phosphor-bronze springs, fixed one on each spindle to lead in and lead out the current. The springs are spiralled in the opposite direction in order to neutralize the effect of temperature changes.

The horseshoe shaped permanent magnet is made of an alloy called 'Alnico' and it has soft iron pole pieces which are shaped to distribute uniform flux in the air gap.

A soft iron core is fixed in such a way that the moving coil can move within the gap, between the soft iron core and the pole pieces. The function of the soft iron core is (i) to decrease the reluctance of the magnetic path between the poles and thereby increase the magnetic flux and (ii) to make the flux uniformly distributed in the air gap.

The pointer is attached to one of the spindles, and it moves on a graduated scale when the coil is deflected by the quantity to be measured.

Operation: When the current is passed through the coil, the coil experiences a force due to the interaction of the magnetic fluxes, produced by the permanent magnet and the current in the moving coil.

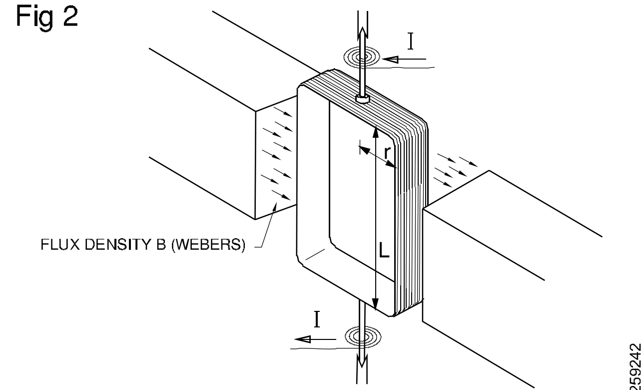
We have the force 'F' in the coil equal to BLIN Newtons Fig 2

where

B - The flux density in the air gap in Webers/ square metre,

L - The active length of one conductor in the air gap in metres

Fig 2



PRINCIPLE OF THE MOVING COIL INSTRUMENT

I - The current in amperes passing through the coil and N is the number of turns.

Torque produced in the coil

= force X perpendicular distance between the centre of the conductor to the centre of the spindle in metres.

Let us assume the distance as 'r'metres.

Hence we have

T = Fr Newton metres

T = BLINr Newton metres.

(F = BLIN Newton)

But B,L,N and r are constants for a particular instrument and can be denoted by a letter 'K'. As such

Torque = KI

Torque proportional to I

From the above equation we can infer that the deflecting torque of a PMMC instrument is directly proportional to the current, and, therefore, the scale of the PMMC instrument is uniform that is the scale in which the space between numbers are equal.

Full scale deflection current: This is the maximum current flowing through the moving coil to give full scale deflection of an instrument.

Meter sensitivity: It is an important characteristic of any meter. The amount of current necessary to cause full scale deflection of the meter pointer is the meter sensitivity. The typical current meter sensitivity varies from about 5 microamperes to 75 milliamperes.

However, the direction of deflection of the moving coil depends upon the direction of the current flowing through the coil. As such, if the instrument is connected with reverse polarity, the deflection of the coil will be reversed, and the pointer will try to move in an anticlockwise direction and read below zero.

Hence, while connecting the instrument in DC the polarity should be correctly observed. Further the instrument will not deflect when connected to an AC supply.

Uses/advantages/disadvantages: As a PMMC instrument is a polarized instrument, it could be used only in DC.

The PMMC instrument could be directly used to measure milli or micro amperes as the moving coil can carry a low current only. With proper shunts, this instrument could be used to measure large currents, and with proper series resistors, called multipliers, it could be converted into a voltmeter. (The procedure of extending the range of an ammeter or converting it into a voltmeter will be dealt with in another lesson.)

Advantages: The PMMC instrument

- consumes less power
- has uniform scale and can cover an arc up to 270°
- has high torque/weight ratio
- can be modified as voltmeter or ammeter with suitable resistors
- has efficient damping
- is not affected by stray magnetic fields, and
- has no loss due to hysteresis.

Disadvantages: The PMMC instrument

- can be used only in DC
- is very delicate
- is costly when compared to a moving iron instrument
- may show errors due to loss of magnetism of the permanent magnet.

Uses :

It can be used as volt meter and Ammeter

Moving-iron instruments

Objectives: At the end of this lesson you shall be able to
- **state the principle of moving-iron instruments - attraction and repulsion type**
- **describe the construction and working of a moving-iron Instrument**
- **state the use, advantages and disadvantages of moving-iron instruments.**

Moving-iron instruments: This instrument derives its name from the fact that a piece of soft iron which is attached to the spindle and needle moves in a magnetic field, produced by the current or by a current proportional to the quantity of electricity being measured.

There are two types of this instrument which are used either as voltmeter or ammeter.

They are:

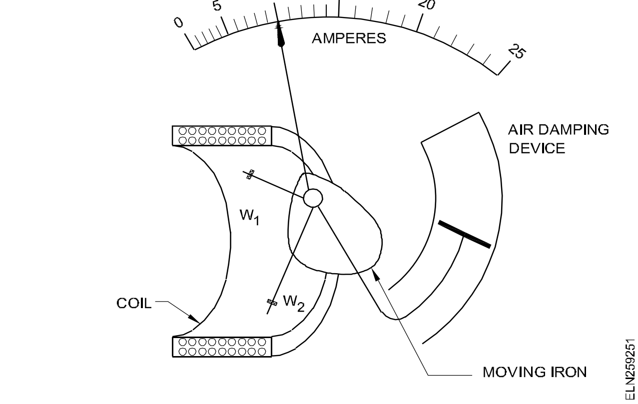
- attraction type
- repulsion type.

Principle of operation: The attraction type instrument works on the principle of magnetic attraction, and the repulsion type instrument works on the principle of magnetic repulsion between two adjacent pieces of soft iron, magnetised by the same magnetic field.

Construction and working of attraction type moving-iron instrument: This instrument consists of an electromagnetic coil having an air core (Fig 1). Just in front of the air core, an oval shaped soft iron piece is eccentrically pivoted in a spindle (Fig 1).

The spindle is free to move with the help of the jewelled bearings, and the pointer, which is attached to the spindle, could thus move over the graduated scale. When the electromagnetic coil is not connected to the circuit, the soft iron piece hangs vertically down, due to gravitational force and the pointer shows zero reading.

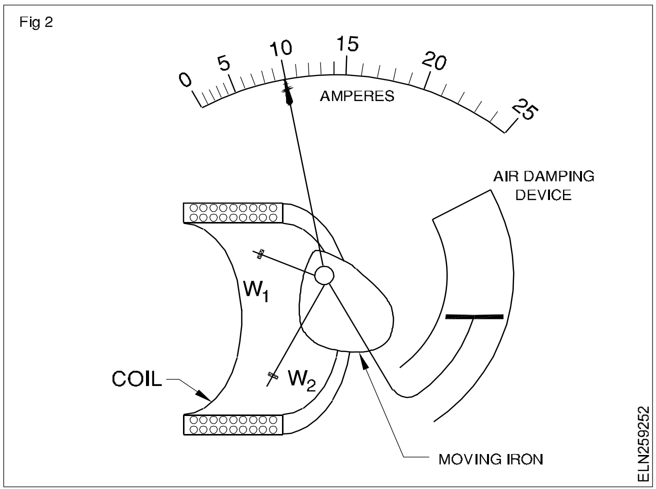
Fig 1



When the electromagnetic coil is connected to the supply, the magnetic field created in the coil attracts the soft iron piece (Fig 2). Due to the eccentricity of pivoting of the iron piece, the enlarged portion of the iron piece is pulled towards the coil. This in turn moves the spindle and makes the pointer to deflect.

The amount of deflection of the pointer will be greater when the current producing the magnetic field is greater. Further the attraction of the soft iron piece is independent on the current direction in the coil. This characteristic enables the instrument to be used both in DC and AC.

Construction and working of repulsion type moving-iron instrument: This instrument consists of a coil wound on a brass bobbin B, inside which two strips of soft iron M and F are set axially (Fig 3a). Strip F is fixed whereas the iron strip M is attached to the spindle S, which also carries the pointer P.

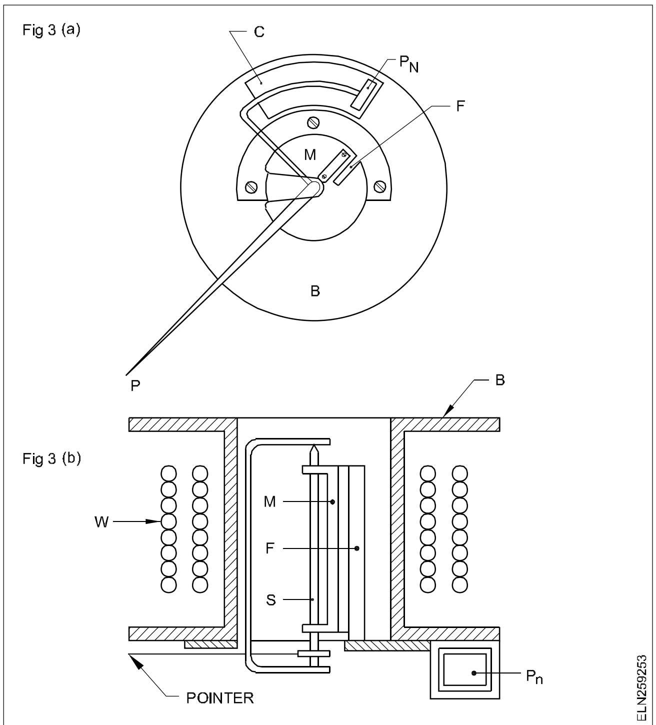


Spring control is used, and the instrument is designed such that when no current is flowing through W, the pointer is at zero position and the soft iron strips M and F are almost touching. (Fig 3a & 3b)

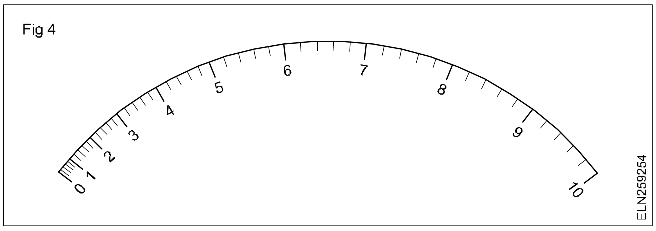
When the instrument is connected to the supply, the coil W carries current which in turn produces a magnetic field. This field makes the fixed and moving-iron F and M respectively to produce similar poles in the ends. Therefore, the two strips repel each other.

The torque set up produces a deflection of the moving system end. Therefore it brings into play a controling torque due to torsion of the control springs or weights. The moving system comes to rest in such a position that the deflecting and controlling torques are equal.

In this type of instrument, air damping is used commonly which is provided by the movement of a piston P_N in a cylindrical air chamber C (Fig 3a).

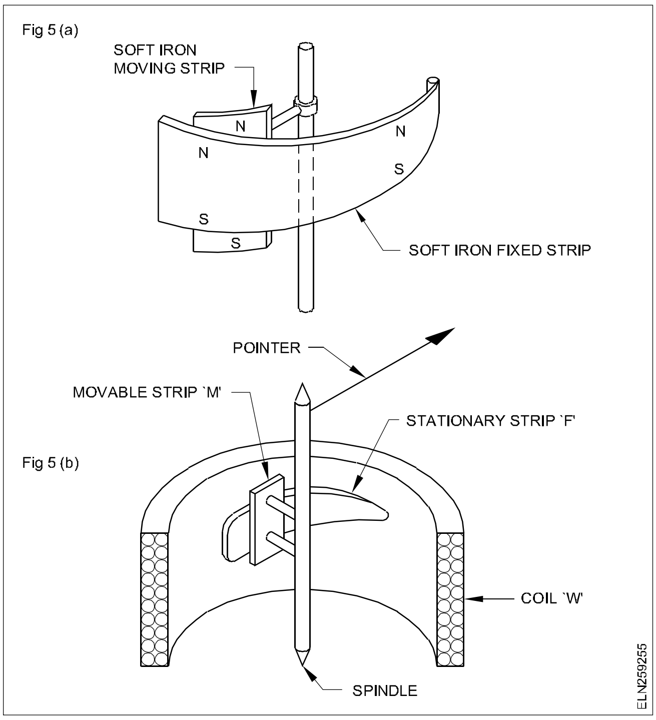


Deflecting torque and graduation of scale: However, in the moving-iron instruments, the deflecting torque is proportional to the square of the current passing through the coil. As such the scale of this instrument will be uneven. It is cramped at the beginning and open at the end (Fig 4).



In order to achieve uniformity of scale, some manufacturers have designed tongue shaped strip as fixed soft iron (Fig 5a).

The fixed iron consists of a tongue-shaped soft iron sheet bent into a cylindrical form, while the moving iron is made of another soft iron sheet, and is so mounted as to move parallel to the fixed iron and towards its narrower end (Fig 5b).



The torque, which is proportional to the square of the current, is proportionally reduced by the narrow portion of the fixed iron, resulting in more or less even torque and thereby uniform scale.

These instruments are either gravity or spring controlled, and the damping is achieved by the air friction method

Uses, advantages and disadvantages of Moving-iron instruments

Uses: They are used as voltmeters and ammeters.

The coil W is wound with thick conductor of less number of turns for ammeters and is wound with thin conductors of large number of turns for voltmeter.

Advantages

- They can be used for both AC and DC, and are hence called unpolorized instruments.
- They have a small value of friction errors as the torque/weight ratio is high.
- They are less costly when compared to the moving coil instruments.
- They are robust owing to their simple construction.
- They have satisfactory accuracy levels within the limits of both precision and industrial grades.
- They have scales covering 240°.

Disadvantages

- They have errors due to hysteresis, frequency changes, wave-form and stray magnetic fields.
- They have non-uniform scales commonly. However, special manufacturing designs are utilized to get more or less uniform scales.

Dynamometer type instrument

Objectives: At the end of this lesson you shall be able to

- **state the principle of dynamometer type instrument**
- **describe the construction, and working of the dynamometer type instruments**
- **explain the internal connections of a dynamometer instrument when used as a voltmeter, ammeter and wattmeter**
- **state the advantages and disadvantages of using the dynamometer instruments.**

Electro-dynamic or Dynamo-meter type Instruments

Working principle: This Instrument works on the principle of DC motor. That is, whenever a current-carrying conductor is kept in a magnetic field, a force is created and it tends to move the conductor away from the magnetic field. In a dynamo- meter instrument, the magnetic field is produced by an electromagnet named as fixed coils.

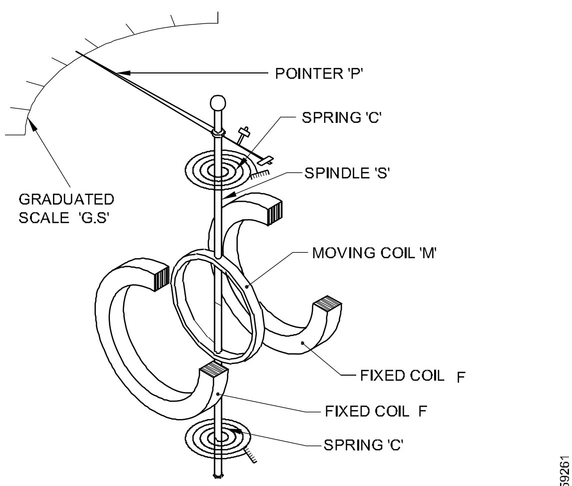
The moving coil, either connected in series or parallel with the fixed coil, carries a proportionate current. Operation of this instrument in both AC and DC is possible due to the fact that when ever the current reverses in AC, the direction of flux in the fixed coils as well as the direction of flux produced by moving coil, reverses at the same time resulting in the same direction of torque.

Construction: A general arrangement of the instrument is shown in Fig 1. The main magnetic field is produced by the fixed/stationary coil. This coil is divided into two sections to give a uniform field in the centre and also to allow the moving coil mechanism to be placed in between them.

The fixed coils F and F are placed close together and parallel to each other (Fig 2). The air core section removes hysteresis effects when used in AC circuits. The moving coil `M' is mounted on a spindle `S' and the spindle is free to move in the air gap with the help of jewelled bearings.

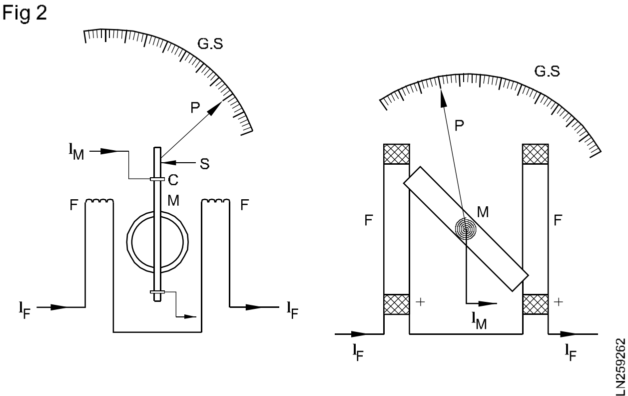
The pointer `P' is attached to one end of the spindle and the spindle end made to move on a graduated scale `G S'. The controlling torque is provided by two phosphor-bronze springs `C' attached to the spindle. Further the springs are used to allow the current `in' and `out' from the moving coil.

Fig 1



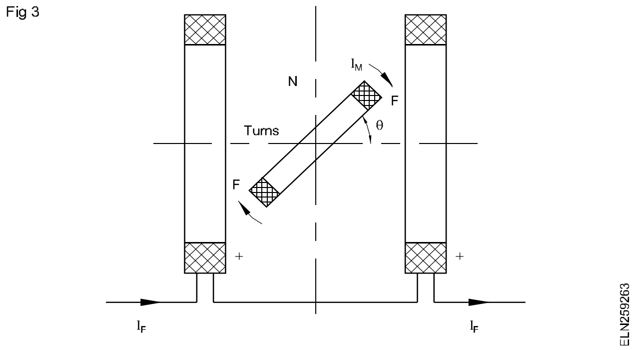
DYNAMOMETER INSTRUMENT

Fig 2



Working: As shown in Fig 3,let the current passing through the fixed coils be I_F, and the current passing through the moving coil be I_M. The field strength will be proportional to the current I_F.

Fig 3



The deflecting torque is produced due to the interactions of the magnetic fields produced by the fixed and moving coils and will be proportional to the current carried by them.

The deflecting torque T_d is proportional to I_F and I_M where I_F is the current in the fixed coil and I_M is the current in the moving coil.

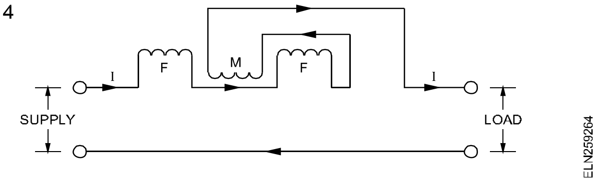
From the above torque equation, it is clear that the instrument when used as voltmeter or ammeter will have ununiform scale due to the square law response.

However, when used as a wattmeter, the instrument will have uniform scale.

Connection of this instrument requires modification depending up on the usage viz, ammeter, voltmeter or wattmeter as explained below.

Dynamometer instrument as an ammeter: This instrument could be used as milli or micro ammeter by connecting the fixed and moving coils in series (Fig 4).

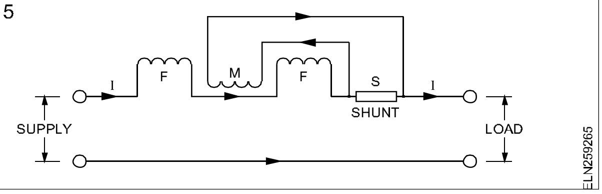
Fig 4



As the moving coil is made by winding small gauge (thin) wire, the above connection is unsuitable for measuring heavy currents.

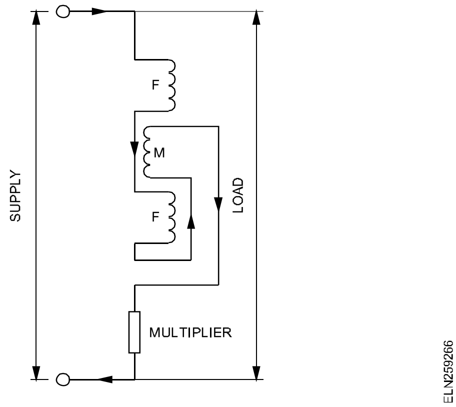
When the instrument is to be converted as an ammeter to measure large currents, the moving coil is connected across a shunt (Fig 5). Both AC and DC, measurements are possible.

Fig 5



Dynamometer instrument as a voltmeter: When this instrument is used as voltmeter, the fixed and moving coils are joined in series along with a high resistance (multiplier) (Fig 6). This voltmeter could be used both in AC and DC.

Fig 6



Dynanometer used as a Wattmeter: The dynamometer is commonly used as a wattmeter to measure power in both AC and DC circuits and will have uniform scale.

Advantages :

- This instrument can be used both in AC and DC.
- As this is an air cored instrument, the hysteresis and eddy current losses are eliminated.
- This instrument has better accuracy.
- When used as wattmeter, the scale is uniform.

Disadvantages :

- It is more expensive than PMMC and moving iron instruments.
- When used as voltmeter or ammeter the scale will not be uniform.
- It has a low torque/weight ratio-as such has low sensitivity.
- Sensitive for over loads and mechanical impact. Hence careful handling is necessary.
- It consumes more power than PMMC meters.

Digital Ammeter

Objectives: At the end of this lesson you shall be able to
- **state the features of digital ammeter**
- **state the movements, special operation and standard.**

Digital Ammeter

Digital Ammeters are instruments that measure the current in ampere and display it in digital. These instruments provide information about current drawn and current continuty to help users troubleshoot electric loads.

They have both positive and negative leads and low internal resistance. Digital ammeters are connected in series with a circuit so that current flow passes through the meter.

High current flow may indicate short circuit (or) defective component. Low current flow may indicate high resistance. It can be used to measure the A.C and D.C. Many digital ammeters include a current sensor built in the meter or that is clamped around the wire.

Features:

Different types of digital ammeters can measure different ranges of A.C current and D.C current and also A.C frequency.

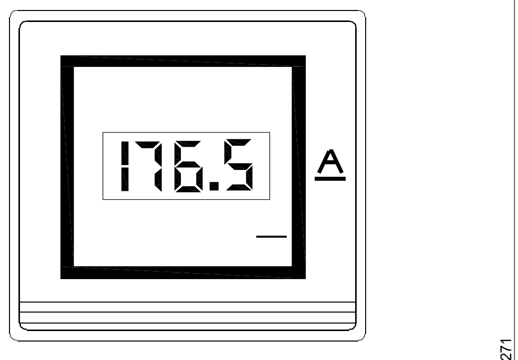
Batteries are provided in it to operate without plug-in-power and suitable for cutdoor use Fig 1 shows a typical digital ammeter.

Special measurements and advanced option:

In some of advanced option, digital ammeters can

- Adjust sampling rates automatically

Fig 1



TYPICAL DIGITAL AMMETER

- Display status information as bar graph
- Measure decibel readings

Standards :

Digital ammeters must have a certain standards and specifications to ensure proper design and functionality refer IEC 600 51 - 2.

Digital Volt Meter (DVM)

Objectives: At the end of this lesson you shall be able to
- **distinguish between analogue and digital voltmeter**
- **list out the advantage of DVM**
- **explain the working principle of DVM.**

Digital Volt Meter (DVM) :

The Digital Volt Meter(DVM) is an electrical measureing instrument which is used to measure line potential difference (P.D) between two points. The voltage to be measured may be AC or DC. Two types of voltmeters are available for the purpose of voltage measurement i.e. analog and digital. Analog voltmeters generally contain a dial with a needle moving over it according to the measure and hence displaying the value of the same.

Digital voltmeters display the value of AC or DC voltage being measured directly as discrete numerical instead of a pointer deflection on a continuous scale as in analog instruments.

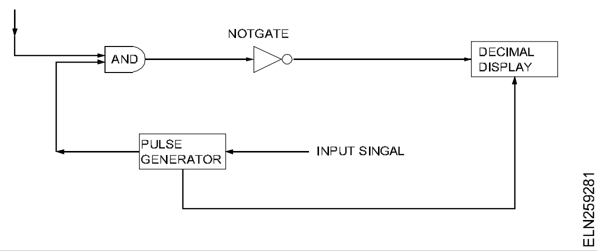
Advantages of Digital Voltmeters:

- Read out of DVMs is easy as it eliminates observational errors in measurement
- Parallax error is eliminated
- Reading can be taken very fast
- Output can be fed to memory devices for storage and future computations
- More versatile and accurate
- Compact portable and cheap
- Requires low power

Working Principle of Digital Voltmeter:

The block diagram of a simple digital voltmeter is shown in the Fig 1 It consists the following blocks

Fig 1



Input signal: It is basically the signal of voltage to be measured.

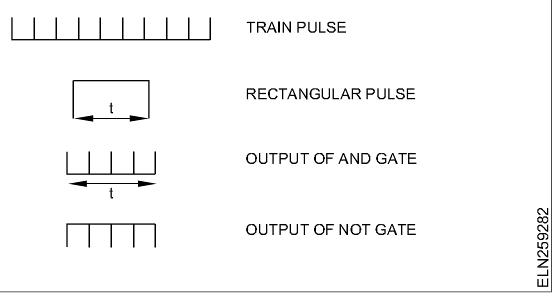
Pulse generator: Actually it is a voltage source. It uses digital, analog or both techniques to generate a rectangular pulse. the width and frequency of the rectangular pulse is controlled by the digital circuit inside the generator while amplitude with rise and fall time is controlled by analog circuitry

AND gate: It gives high output only when both the input are high, when a train pulse is fed to it along with rectangular pulse, it provides output having train time duration as same and the rectangular pulse from the pulse generator.

Decimal Display: It counts the numbers of impulses and display the value of voltage on LED or LCD display after calibrating it.

Working (Fig 2)

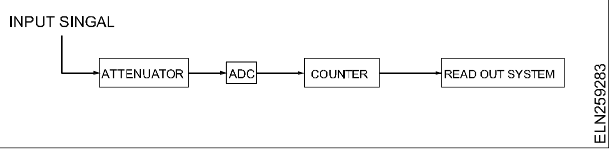
Fig 2



- Unknown voltage signal is fed to the pulse generator which generates a pulse whose width is proportional to the input signal.
- Output of pulse generator is fed to one leg of the AND gate.
- The input signal to the other leg of the AND gate is a train of pulses.
- Output of AND gate is positive triggered train of duration same as the width of the pulse generated by the pulse generator.
- This postitive triggered train is fed to the inverter which converts it into a negative triggered train.
- Output of the inverter is fed to a counter which counts the number of triggers in the duration which is proportional to the input signal i.e. voltage under measurement

This counter can be calibrated to indicate voltage in volts converts an analog signal into a train of pulses, the number is proportional to the input signal. So a digital voltmeter can be made by using any one of the A/D conversion methods (Fig 3)

Fig 3



On the basis of A/D conversion method used digital voltmeters can be classified as:

- Ramp type digital voltmeter.
- Intergrating type voltmete.
- Potentiometric type digital voltmeter.
- Succesive approximation type digital voltmeter.
- Continuous balance type digital voltmeter.

Now-a- days digital voltmeters are also replaced by digital multi meters due to its multitasking feature.