PNS SCHOOL OF ENGINEERING & TECHNOLOGY

NishamaniVihar, Marshaghai, Kendrapara

LECTURES NOTES ON

ELECTRONICS MEASUREMENT & INSTRUMENTATION

DEPARTMENT OF ELECTRONICS &TELECOMMUNICATION

3RDSEMESTER

<u>**PREPAREDBY**</u>

Er.AMARENDRA SAHOO

HOD,

ELECTRONICS & TELECOMMUNICATION ENGG.

Detailed Contents:

Unit-1: Qualities of Measurement

1.1 Discuss the Static Characteristics,

1.2 Define accuracy, sensitivity, reproducibility & static error of instruments

1.3 Discuss the dynamic characteristic

1.4Define speed of instruments

1.5Define errors of an instruments & explain various type

CHAPTER-1

Qualities of Measurement

INSTRUMENT-

It is a device for determining values or magnitude of a quantity or variable through a given set of formula.

MEASUREMENT-

It is a process of comparing an unknown quantity with an accepted standard quantity.

ELECTRONICS MEASUREMENT & INSTRUMENTATION

It is the branch of electronics which deals with the study of measurement and variation of different parameters of various instruments.

Q. Why different parameters and study of variation for a particular instruments are required?

Ans.-The measurement of parameters and its variations for a particular instrument is required because it helps in understanding the behavior of an instrument.

CONDITION FOR A MEASURING INTRUMENT

The measuring instrument must not affect the quantity which is to be measured.

MEASUREMENT SYSTEM PERFORMANCE:-

The performances of the measurement of the measurement system are divided into two categories.

1 . Static Characteristics

2 . Dynamic Characteristics

1. Static Characteristics of instruments

These are those characteristics of an instrument which do not vary with time and are generally considered to check if the given instrument is fit to be used for measurement. The static characteristics are from one form or another by the process called Calibration.

They are as follows:-

1. **ACCURACY-**
2. It is defined as the ability of a device or a system to respond to a true value of a measure variable under condition.

2. PRECISION-

Precision is the degree of exactness for which an instrument is design or intended to perform.

3. REPEATABILITY-

The repeatability is a measuring device may be defined as the closeness of an agreement among a number of consecutive measurements of the output for the same value of the input under save operating system.

4. REPRODUCIBILITY-

Reproducibility of an instrument is the closeness of the output for the same value of input. Perfect reproducibility means that the instrument has no drift. 5. SENSITIVITY- Sensitivity can be defined as a ratio of a change output to the change input at steady state condition.

6. RESOLUTION-

Resolutions the least increment value of input or output that can be detected, caused or otherwise discriminated by the measuring device.

7. TRUE VALUE-

True value is error free value of the measure variable it is given as difference between the Instrument Reading and Static error. Mathematically,

True value= Obtained Instrument reading – static error.

Note- %Error =

2.2. DYNAMIC CHARACTERISTICS OF INSTRUMENT

The Dynamic Characteristics are those which change within a period of time that is generally very short in nature.

1. SPEED OF RESPONSE-It is the rapidity with which an instrument responds to the changes to in the measurement quantity.

2. FIDELITY-

The degree to which an instrument indicate the measure variable without dynamic error.

3. LAG-

It is retardation or delay in the response an instrument to the changes in the measurement. 2.3. **ERROR-**

The deviation or change of the value obtained from measurement from the desired standard value. Mathematically, Error = Obtained Reading/Value – Standard Reference Value. There are three types of error. They are as follows:- 1.

GROSS ERRORS-

This are the error due to humans mistakes such as careless reading mistakes in recoding observation incorrect application of an instrument.

A. **SYSTEMATIC ERROR-**
B. A constant uniform deviation of an instrument is as systematic error. There are two types of systematic error.

a) STATIC ERROR :

The static error of a measuring instrument is the numerical different between the true value of a quantity and its value as obtained by measurement.

b) DYNAMIC ERROR1. It is the different between true value of a quantity changing with and value indicated by the instrument.

2. The Dynamic Errors are caused by the instrument not responding fast enough to follow the changes in the measured value.

B. RANDOM ERROR-The cause of such error is unknown or not determined in the ordinary process **of making measurement .**

TYPES OF STATIC ERROR

i. INSTRUMENTAL ERROR-

Instrumental error are errors inherent in mastering instrument because of the mechanical construction friction is bearing in various moving component. It can be avoided by

a. Selecting a suitable instrument for the particular measurement.

b. Applying correction factor after determining the amount of instrumental error.

ii. ENVIROMENTAL ERROR –

Environmental error are due to conditions external to the measuring device including condition al in the area surrounding the instrument such as effect of change in temperature , humidity or electrostatic field it can be avoided

a. Providing air conditioning.

b. Use of magnetic shields.

iii. OBSERVATIONAL ERROR-

The errors introduced by the observer. These errors are caused by habits of the observers like tilting his/her head too much while reading a “Needle – Scale Reading”.

CHAPTER-02

INDICATING INSTRUMENT

2.1. INTRODUCTION

2.1.1. MEASURING INSTRUMENTS:-

Measuring instruments are classified according to both the quantity measured by the instrument and the principle of operation.

There are three general principles of operation: electromagnetic, which utilizes the magnetic effects of electric currents;¬ electrostatic, which utilizes the forces between electrically-charged conductors; Electro-thermic , which utilizes the heating effect.

The essential requirements of measuring instruments are:-

It must not alter the circuit conditions.

It must consume very small amount of power.

Electric measuring instruments and meters are used to indicate directly the value of current, voltage, power or energy.

An electromechanical meter (input is as an electrical signal results mechanical force or torque as an output) that can be connected with additional suitable components in order to act as an ammeters and a voltmeter.

The most common analogue instrument or meter is the permanent magnet moving coil instrument and it is used for measuring a dc current or voltage of an electric circuit.

1. 2.1.2. TYPES OF FORCES/TORQUES ACTING IN MEASURING INSTRUMENTS:

DEFLECTING TORQUE/FORCE:

The defection of any instrument is determined by the combined effect of the deflecting torque/force, control torque/force and damping torque/force. The value of deflecting torque must depend on the electrical signal to be measured. This torque/force causes the instrument movement to rotate from its zero position.

2. CONTROLLING TORQUE/FORCE:

This torque/force must act in the opposite sense to the deflecting torque/force, and the movement will take up an equilibrium or definite position when the deflecting and controlling torque are equal in magnitude. The Spiral springs or gravity usually provides the controlling torque.

3. DAMPING TORQUE/FORCE:

A damping force is required to act in a direction opposite to the movement of the moving system. This brings the moving system to rest at the deflected position reasonably quickly without any oscillation or very small oscillation.

This is provided by

I)Air friction

ii) Fluid friction

iii) Eddy current.

It should be pointed out that any damping force deflection produced by a given deflecting force or torque. Damping force increases with the angular velocity of the moving system, so that its effect is greatest when the rotation is rapid and zero when the system

2.2. BASIC METER MOVEMENT &PMMC MOVEMENT

2.2.1. BASIC METER MOVEMENT OR D’ARSONVAL METER MOVEMENT PRINCIPLE:-

Whenever electrons flow through a conductor, a magnetic field proportional to the current is created. This effect is useful for measure.

The basic dc meter movement is known as the D'Arsonval meter movement because it¬ was first employed by the French scientist, D'Arsonval, in making electrical measurement.

This type of meter movement voltmeter, and ohmmeter. An ohmmeter is also basically a current measuring instrument,ammeter and voltmeter in that it provides its own source of power and contains other auxiliary circuits.

D’ARSONVAL GALVANOMETER:

This instrument is very commonly used in various methods of resistance measurement and also in d.c. potentiometer work. shown in figure below

MOVING COIL:

It is the current carrying element.

It is either rectangular or circular in shape and consists of number of turns of fine wire.

This coil is suspended so that it is free to turn about its vertical axis of symmetry

It is arranged in a uniform, radial, horizontal magnetic field in the air gap between pole pieces of a permanent magnet and iron core.

ii) Fluid friction

iii) Eddy current.

It should be pointed out that any damping force shall not influence the steady state deflection produced by a given deflecting force or torque.

Damping force increases with the angular velocity of the moving system, so that its effect is greatest when the rotation is rapid and zero when the system rotation is zero.

BASIC METER MOVEMENT &PMMC MOVEMENT BASIC METER MOVEMENT OR D’ARSONVAL METER MOVEMENT

Whenever electrons flow through a conductor, a magnetic field proportional to the current is created.

This effect is useful for measuring current and is employed in many practical meters.

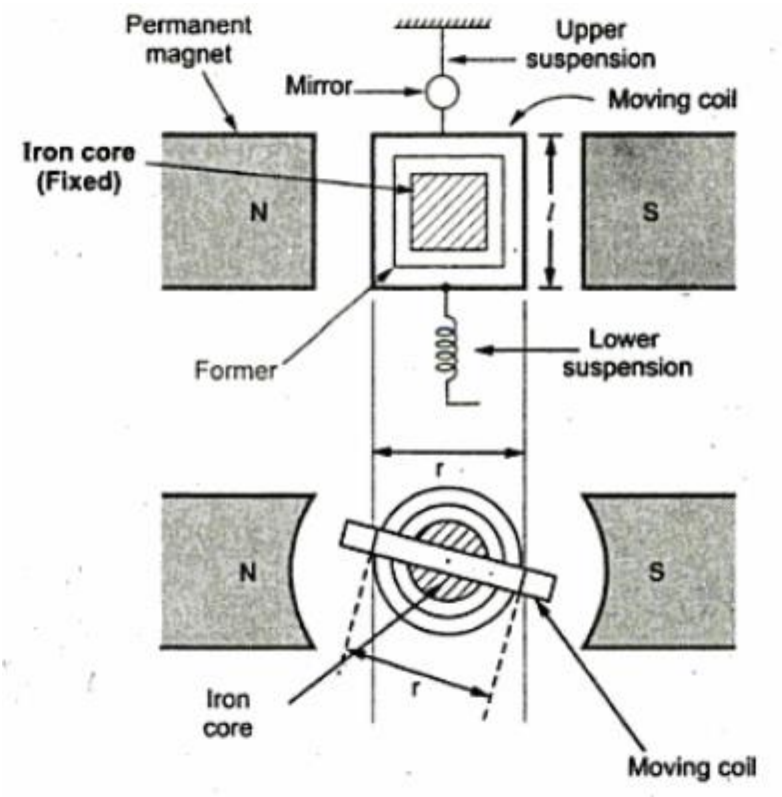
The basic dc meter movement is known as the D'Arsonval meter movement because it was first employed by the French scientist, D'Arsonval, in making electrical.

This type of meter movement is a current measuring device which is used in the ammeter, voltmeter, and ohmmeter.

An ohmmeter is also basically a current measuring instruments, it differs from the ammeter and voltmeter in that it provides its own source of power and contains other

D’ARSONVAL GALVANOMETER:

This instrument is very commonly used in various methods of resistance measurement and . potentiometer work.



MOVING COIL:-

It is the current carrying element.

It is either recatangular or circular in shape and consists of number of turns of fine wire.

This coil is suspended so that it is free to move /turn about its vertical axis of symmetry.

It is arranged in a uniform, radial, horizontal magnetic field in the air gap between pole]

The iron core is spherical in shape if the coil is circular but is cylindrical if the coil is rectangular.

The iron core is used to provide a flux path of low reluctance and therefore to provide strong magnetic field for the coil to move in.

This increases the deflecting torque and hence the sensitivity of the galvanometer.

The length of air gap is about 1.5mm.

In some galvanometers the iron core is omitted resulting in of decreased value of flux density and the coil is made narrower to decrease the air gap.

Such a galvanometer is less sensitive, but its moment of inertia is smaller on account of its reduced radius and consequently a short periodic time.

DAMPING:

There is a damping torque present owing to production of eddy currents in the metal¬ former on which the coil is mounted.

Damping is also obtained by connecting a low resistance across the galvanometer terminals.

Damping torque depends upon the resistance and we can obtain critical damping by adjusting the value of resistance.

3) SUSPENSION:

The coil is supported by a flat ribbon suspension which also carries current to the coil. The other current connection in a sensitive galvanometer is a coiled wire. This is called¬ the lower suspension and has a negligible torque effect.

This type of galvanometer must be leveled carefully so that the coil hangs straight and centrally without rubbing the poles or the soft iron cylinder.

The upper suspension consists of gold or copper wire of nearly 0.012-5 or 0.02-5 mm diameter rolled into the form of a ribbon.

This is not very strong mechanically so that the galvanometers must he handled carefully without jerks.

4) INDICATION:

The suspension carries a small mirror upon which a beam of light is cast. The beam of light is reflected on a scale upon which the deflection is measured.

This scale is usually about 1 meter away from the instrument, although ½ meter may be used for greater compactness.

5) ZERO SETTING:

A torsion head is provided for adjusting the position of the coil and also for zero setting.

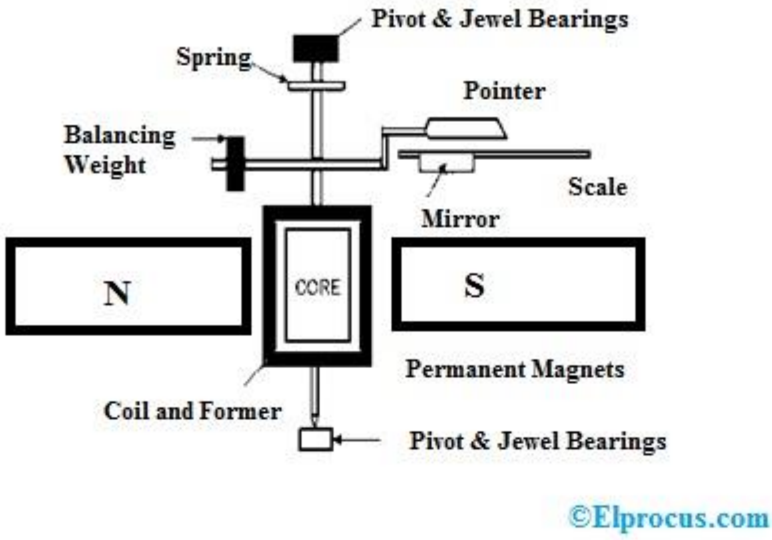
2.2.2 .PMMC INSTRUMENTS:

These instruments are used either as ammeters or voltmeters and are suitable for d.c work only.

PMMC instruments work on the principle that, when a current carrying conductor is placed in a magnetic field, a mechanical force acts on the conductor.

The current carrying coil, placed in magnetic field is attached to the moving system.

With the movement of the coil, the pointer moves over the scale to indicate the electrical quantity being measured. This type of movement is known as D' Arsenoval movement.



CONSTRUCTION:

It consists of a light rectangular coil of many turns of fine wire wound on an aluminium former inside which is an iron core as shown in fig.

The coil is delicately pivoted upon jewel bearings and is mounted between the pol permanent horse shoe magnet.

Two soft-iron pole pieces are attached to these poles to concentrate the magnetic field.

The current is led in to and out of the coils by means of two control hair above and other below the coil, as shown in Fig.

These springs also provide the controlling torque. The damping torque is provided by eddy currents induced in the all another.

WORKING:

When the instrument is connected in the circuit to measure current or voltage, the operating current flows through the coil.

Since the current carrying coil is placed in the magnetic mechanical torque acts on it. As a result of this torque, the pointer attached to the moving system moves in clockwise direction over the graduated scale to indicate the value of current or voltage being measured. This type of instruments can be used to measure direct current only.

This is because, since the direction of the field of permanent magnet is same, the¬ deflecting torque also gets reversed, when the current in the coil reverses.

Consequently, the pointer will tr direction can be prevented by a “stop” spring. It consists of a light rectangular coil of many turns of fine wire wound on an aluminium former inside which is an iron core as shown in fig.

The coil is delicately pivoted upon jewel bearings and is mounted between the pol permanent horse shoe magnet. iron pole pieces are attached to these poles to concentrate the magnetic field.

The current is led in to and out of the coils by means of two control hair above and other below the coil, as shown in Fig.

These springs also provide the controlling torque.

The damping torque is provided by eddy currents induced in the aluminum former as the coil moves from one position to

When the instrument is connected in the circuit to measure current or voltage, the operating current flows through the coil.

Since the current carrying coil is placed in the magnetic field of the permanent magnet, a mechanical torque acts on it.

As a result of this torque, the pointer attached to the moving system moves in clockwise direction over the graduated scale to indicate the value of current or voltage being e of instruments can be used to measure direct current only.

This is because, since the direction of the field of permanent magnet is same, the deflecting torque also gets reversed, when the current in the coil reverses. Consequently, the pointer will try to deflect below zero.

Deflection in the reverse direction can be prevented by a “stop” spring. Fig [Page 7] It consists of a light rectangular coil of many turns of fine wire wound on an aluminum .

The coil is delicately pivoted upon jewel bearings and is mounted between the poles of a iron pole pieces are attached to these poles to concentrate the magnetic field. The current is led in to and out of the coils by means of two control hair- springs, one These springs also provide the controlling torque.

The damping torque is provided by aluiuminium former as the coil moves from one position to When the instrument is connected in the circuit to measure current or voltage, the field of the permanent magnet, a As a result of this torque, the pointer attached to the moving system moves in clockwise direction over the graduated scale to indicate the value of current or voltage being This is because, since the direction of the field of permanent magnet is same, the deflecting torque also gets reversed, when the current in the coil reverses. y to deflect below zero. Deflection in the reverse [Page 8]

DEFLECTING TORQUE EQUATION:-

The magnetic field in the air gap is radial due to the presence of soft iron core.

Thus, the conductors of the coil will move at right angles to the field.

When the current is passed through the coil, forces act on its both sides which produce the deflecting torque.

Let, B = flux density, Wb/m2

l = length or depth of coil, m

b = breadth of the coil.

N = no. of turns of the coil.

If a current of 'I' Amperes flows in the coil,

then the force acting on each coil side is given by,

Force on each coil side,

F = BIlN Newtons.

Deflecting torque,

Td = Force × perpendicular distance¬ = (BIlN) × b Td = BINA Newton metre.

Where, A = l × b,

the area of the coil in m2 .

Thus, Td α I.

The instrument is spring controlled so that, Tc α θ.

The pointer will comes to rest at a position, where Td =Tc.

Therefore, θ α I .

Thus, the deflection is directly proportional to the operating current.

Hence, such instruments have uniform scale.

ADVANTAGES:

a) Uniform scale.ie, evenly divided scale.

b) Very effective eddy current damping.

c) High efficiency.

d) Require little power for their operation.

e) No hysteresis loss (as the magnetic field is constant).

f) External stray fields have little effects on the readings (as the operating magnetic field is very strong).

g) Very accurate and reliable.

DISADVANTAGES:

a) Cannot be used for a.c measurements.

b) More expensive (about 50%) than the moving iron instruments because of their accurate design.

c) Some errors are caused due to variations (with time or temperature) either in the strength of permanent magnet or in the control spring.

APPLICATIONS:

a) In the measurement of direct currents and voltages.

b) In d.c galvanometers to detect small currents.

c) In Ballistic galvanometers used for measuring changes of magnetic flux linkages. [Page 9] 2.3. **OPERATION OF MOVING IRON INSTRUMENT**:-

Moving Iron instruments are mainly used for the measurement of alternating currents and voltages, though it can also be used for d.c measurements.

PRINCIPLE OF MOVING IRON INSTRUMENT:-

Let a plate or vane of soft iron or of high permeability steel forms the moving element of¬ the system.

The iron vane is situated so as, it can move in a magnetic field produced by a stationary coil. The coil is excited by the current or voltage under measurement.

When the coil is excited, it becomes an electromagnet and the iron vane moves in such a¬ way so as to increase the flux of the electromagnet.

Thus, the vane tries to occupy a position of minimum reluctance.

Thus, the force produced is always in such a direction so as to increase the inductance of the coil.

TYPES OF MOVING IRON INSTRUMENTS:

There are two types of Moving- iron instruments

ATTRACTION TYPE:

In this type of instrument, a single soft iron vane (moving iron) is mounted on the spindle, and is attracted towards the coil when operating current flows through it.

DEFLECTING TORQUE EQUATION:

The force F, pulling the soft -iron piece towards the coil is directly proportional to¬

a) Field strength (H) produced by the coil.

b) Pole strength (m) developed in the iron piece.

$F \alpha Mh$

Since $m \alpha H$,

Therefore $F \alpha H2$

Instantaneous deflecting torque $\alpha H2$.

The field strength $H = \mu i$.

If the permeability (μ) of the iron is assumed constant,

Then $H \alpha I$.

instantaneous coil current (Ampere).

→Where i Instantaneous deflecting torque $\alpha i2$.

Average deflecting torque, $Td \alpha$ mean of $i2$ over a cycle.

Since the instrume¬nt is spring controlled, hence $Tc \alpha \theta$. [Page 10]

In the steady position of deflection, $Td = Tc$.

Therefore $\theta \alpha$ mean of $i2$ over a cycle =¬> $\theta \alpha I2$ (mean of $i2$ over a cycle = $I2$).

Since the deflection is proportional to the square of coil current, the scale of such instruments is non-uniform (being crowded in the beginning and spread out near the finishing end of the scale).

REPULSION TYPE:-

In this two soft iron vanes are used; one fixed and attached the stationary coil, while the other is movable (moving iron), and mounted on the spindle of the instrument.

When operating current flows through the coil, the two vanes are magnetized, developing¬ similar polarity at the same ends.

Consequently, repulsion takes place between the vanes and the movable vane causes the pointer to move over the scale. It is of two types:-

a)Radial vane type: - vanes are radial strips of iron.

b) Co-axial vane type:-vanes are sections of coaxial cylinders.

DEFLECTING TORQUE:

The deflecting torque results due to repulsion between the similarly charged soft- iron¬ pieces or vanes.

If the two pieces develop pole strength of m1 and m2 respectively, then Instantaneous¬ deflecting torque is α m1m2 α H2 .

If the permeability of iron is assumed constant, then H α i,

Where i is the coil current.

Instantaneous deflecting torque α i¬ 2 .

Average deflecting torque, Td α mean of i 2 over a cycle.

Since the instrument is spring controlled, Tc α θ.

In the steady position of deflection,

Td = Tc i.e. θ α mean of i 2 over a cycle => θ α I2 (mean of i2 over a cycle = I2).

Thus, the deflection is proportional to the square of the coil current.

The scale of the instrument is non- uniform being crowded in the beginning and spread out near the finish end of the scale.

However, the non- linearity of the scale can be corrected to some extent by the accurate shaping and positioning of the iron vanes in relation to the operating coil.

2.4. PRINCIPLE OF OPERATION OF DC AMMETER AND MULTIRANGE AMMETER

D.C. AMMETER:-

The PMMC galvanometer constitutes the basic movement of a dc ammeter.¬

The coil winding of a basic movement is small and light, so it can carry only very small¬ currents.

A low value resistor (shunt resistor) is used in DC ammeter to measure large current.¬ PMMC movement can be used as DC ammeter by connecting resistor in shunt with it, so that shunt resistance allows a specific fraction of current [excess current greater than full scale deflection current (IFSD)] flowing in the circuit to bypass the meter movement. [Page 11]

The fractions of the current flowing in the movement indicate the total current flowing in the circuit.

DC ammeter can be converted into multirange ammeter by connecting number of resistances called multiplier in parallel with the PMMC movement.

Let Rm = internal resistance of the movement.

I = full scale current of the ammeter + shunt (i.e. total current)

Rsh = shunt resistance in ohms.

Im = full-scale deflection current of instrument in ampere.

Ish = (I- Im) = shunt current in ampere.

Since the shunt resistance is in parallel with the meter movement, the voltage drop across¬ the shunt and movement must be the same.

Therefore,

$Vsh = Vm$¬ $IshRsh = ImRm$,

$Rsh = (ImRm)/Ish$

But $Ish = I – Im$

Hence $Rsh = (ImRm) / (I-Im)$.

$(I-Im)/Im = Rm/Rsh$

$(I/Im)-1 = Rm/Rsh$

$I/Im = 1+ Rm/Rsh$.

The ratio of the total current to the current in the movement is called Multiplying Power¬ of the Shunt i.e

Mathematically,

Multiplying Power $(m) =I/Im = 1+ Rm/Rsh$.

2.4.2. MULTIRANGE DC AMMETER:

The range of the dc ammeter is extended by a number of shunts, selected by a range¬ switch. Such a meter is known as Multi range DC Ammeter.

The resistors is placed in parallel to give different current ranges.

Fig.2.5 Above figure shows a diagram of multi range ammeter.

The circuit has 4 shunts Rsh1, Rsh2, Rsh3 and Rsh4 which can be put in parallel with meter movement to give 4 different current ranges I1, I2, I3and I4.

Let m1, m2, m3 and m4 be the shunt multiplying powers for currents I1, I2, I3 and I4. $Rsh1 = Rm/(m1-1)$

$Rsh2 = Rm/(m2-1)$

$Rsh3 = Rm/(m3-1)$

$Rsh4 = Rm/(m4-1)$

In the Ammeter the multi position make-before-break switch is used.

This type of switch is essential in order that meter movement is not damaged when changing from the current range one to another.

If we provide an ordinary and therefore it can be damaged when the range is changed.

Ammeters are used for the range from the 1 to 50 A.

2.5. AC AMMETER AND MULTIRANGE AMMETERS:

The PMMC movement cannot be used directly for ac measurements since the inertia of¬ PMMC acts as an averager. Because A.C. current has zero average value and it produces a torque that has also zero¬ average value, the pointer just vibrates around zero on th In order to make ac measurements, a bridge rectifier circuit is combined with PMMC as¬ shown below.

2.6. BASIC OPERATION OF OHMMETER:

2.7. ELECTRICAL RESISTANCE:

Electrical resistance is a measure of how much an object opposes allowing an electrical current to pass through it. OHMMETER:

It is an electronic device used to measure electrical resistance of a circuit element of low degree of accuracy.

This resistance reading is indicated through a meter movement.

This type of switch is essential in order that meter movement is not damaged when changing from the current range one to another. If we provide an ordinary switch the meter remains without a shunt and it is unprotected and therefore it can be damaged when the range is changed.

Multirange Ammeters are used for the range from the 1 to 50 A.

AC AMMETER AND MULTIRANGE AMMETERS:.

The PMMC movement cannot be used directly for ac measurements since the inertia of PMMC acts as an averager.

Because A.C. current has zero average value and it produces a torque that has also zero average value, the pointer just vibrates around zero on the scale. In order to make ac measurements, a bridge rectifier circuit is combined with PMMC as Fig.

BASIC OPERATION OF OHMMETER: ELECTRICAL RESISTANCE:

Electrical resistance is a measure of how much an object opposes allowing an electrical current to pass through it.

It is an electronic device used to measure electrical resistance of a circuit element of low reading is indicated through a meter movement. [Page 12]

This type of switch is essential in order that meter movement is not damaged when switch the meter remains without a shunt and it is unprotected

The PMMC movement cannot be used directly for ac measurements since the inertia of Because A.C. current has zero average value and it produces a torque that has also zero In order to make ac measurements, a bridge rectifier circuit is combined with PMMC a

The ohmmeter must then have an internal source of voltage to create the necessary current to operate the movement, and also have appropriate ranging resistors to allow desired current to flow through the movement at any given resistance.

An ohmmeter is useful for¬

1. Determining the approximate resistance of circuit components such as heater elements or machine field coils.

2. Measuring and sorting of resistors used in electronic circuits.

3. Checking of semiconductor diodes and for checking of continuity of circuit.

4. To help the precision bridge to calculate the approximate value of resistance which can save time in balancing the bridge.

There are two types of schemes are used to design an ohmmeter

a) series type

b) shunt type.

The series type of ohmmeter is used for measuring relatively high values of resistance,¬ while the shunt type is used for measuring low values of the resistance.

Fig. Ohmmeters come with different levels of sensitivity.

Some Ohmmeters are designed to measure low-resistance materials, and some are used¬ for measuring high-resistance materials.

A Micro Ohmmeter is used to measure extremely low resistances with high accuracy at particular test currents and is used for bonding contact applications.

Mega Ohmmeter is used to measure large resistance values.

Milli-Ohmmeter is used to measure low resistance at high accuracy confirming the value of any electrical circuit.

SERIES TYPE OHMMETER:

It consists of basic d’Arsonval movement connected in parallel with a shunting resistor R2.

This parallel circuit is in series with resistance R1 and a battery of emf E.

The series circuit is connected to the terminals A and B of unknown resistor Rx

From the figure,

R1 = current limiting resistor;

R Rm = internal resistance of d’Arsonval movement.

When the unknown resistance R flows through the meter.

Under this con movement meter indicates full scale current Ifs. The full scale current position of the pointer is marked “0Ω” on the scale.

Similarly when Rx is removed from circuit R open), the current in the meter drops to the zero and the movement indicates zero current which is the marked “ .

Thus the meter will read infinite resistance at the zero current position and zero resistance at full scale current position.

Since zero resistance is indicated when current in the meter is the maximum and hence the pointer goes to the top mark.

When the unknown resistance is inserted at terminal A, B the current through the meter is reduced and hence pointer drops lower on the scale.

Therefore the meter has “0” at extreme right and “ Intermediate scale marking may be placed on the scale by different known values of the resistance Rx to the instrument.

A convenient quantity to use in the design of the series ohmmeter is Rx which causes the half scale deflection of the meter. At this position, the resistance across terminals A and B is defined as the half scale¬ position resistance Rh.

The design can be approached by recognizing the fact that when R across A and B the meter current reduces to one half of its full scale value or with R = Rh,

Im = 0.5 Ifs, where I for full scale deflection.

This clearly means that R into terminals A and B. Fig = current limiting resistor; R2 = zero adjusting resistor; E = emf of internal battery; = internal resistance of d’Arsonval movement.

When the unknown resistance Rx = 0 (terminals A and B shorted) maximum current flows through the meter. Under this condition resistor R2 is adjusted until the basic movement meter indicates full scale current Ifs.

The full scale current position of the pointer is marked “0Ω” on the scale. is removed from circuit Rx = ∞ (i.e. when terminal A and B are pen), the current in the meter drops to the zero and the movement indicates zero current which is the marked “∞”.

Thus the meter will read infinite resistance at the zero current position and zero resistance at full scale current position. stance is indicated when current in the meter is the maximum and hence the pointer goes to the top mark. When the unknown resistance is inserted at terminal A, B the current through the meter is reduced and hence pointer drops lower on the scale. re the meter has “0” at extreme right and “∞” at the extreme left. Intermediate scale marking may be placed on the scale by different known values of to the instrument.

A convenient quantity to use in the design of the series ohmmeter is which causes the half scale deflection of the meter.

At this position, the resistance across terminals A and B is defined as the half scale .

The design can be approached by recognizing the fact that when R across A and B the meter current reduces to one half of its full scale value or with R , where Im = current through the meter, Ifs = current through the meter for full scale deflection.

This clearly means that Rh is equal to the internal resistance of the ohmmeter looking into terminals A and B. [Page 14] = zero adjusting resistor; E = emf of internal battery; = 0 (terminals A and B shorted) maximum current is adjusted until the basic

The full scale current position of the pointer is marked “0Ω” on the scale. ∞ (i.e. when terminal A and B are pen), the current in the meter drops to the zero and the movement indicates zero

Thus the meter will read infinite resistance at the zero current position and zero stance is indicated when current in the meter is the maximum and When the unknown resistance is inserted at terminal A, B the current through the ∞” at the extreme left.

Intermediate scale marking may be placed on the scale by different known values of A convenient quantity to use in the design of the series ohmmeter is the value of the At this position, the resistance across terminals A and B is defined as the half scale

The design can be approached by recognizing the fact that when Rh is connected across A and B the meter current reduces to one half of its full scale value or with Rx = current through the meter he internal resistance of the ohmmeter looking

This circuit consists of a battery in series with an adjustable resistor R1 and a basic¬ D'Arsonval movement (meter).

The unknown resistance is connected across terminals A and B, parallel with the meter.

In this circuit it is necessary to have an ON-OFF switch to disconnect the battery from the circuit when the instrument is not in use.

When the unknown Resistor Rx= 0Ω, (i.e. A and B are shorted), the meter current is zero.¬ If the unknown Resistor Rx=∞Ω, (i.e. A and B are open), the meter current flows only¬ through the meter and by selecting a proper value of the resistance R1, the pointer may be made to read full scale.

This ohmmeter therefore, has zero marking on the left hand side of the scale (no current) and ∞ mark on the right hand side of the scale

2.7. ANALOG MULTIMETER:-

The main part of an analog multi meter is the D'Arsonval meter movement also known as the permanent-magnet moving-coil (PMMC) movement.

This common type of movement is used for dc measurements.

When the meter current Im flows in the wire coil in the direction indicated in figure a magnetic field is produced in the coil.

This electrically induced magnetic field interacts with the magnetic field of the horseshoe-type permanent magnet.

The result of such an interaction is a force causing a mechanical torque to be exerted on the coil. Since the coil is wound and permanently fixed on a rotating cylindrical drum as shown, the torque produced will cause the rotation of the drum around its pivoted shaft.

When the drum rotates, two restraining springs, one mounted in the front onto the shaft and the other mounted onto the back part of the shaft, will exhibit a counter torque opposing the rotation and restraining the motion of the drum.

This spring-produced counter-torque depends on the angle of deflection of the drum, θ or the pointer. At a certain position (or deflection angle), the two torques are in equilibrium.

Each meter movement is characterized by two electrical quantities

a) Rm: the meter resistance which is due to the wire used to construct the coil

b) IFS: the meter current which causes the pointer to deflect all the way up to the fullscale position on the fixed scale.

This value of the meter current is always referred to as the full scale current of the meter movement. The PMMC movement cannot be used directly for ac measurements since the inertia of PMMC acts as an averager.

Since ac current has zero average value and it produces a torque that has also zero average value, the pointer just vibrates around zero on the scale.

3rd CHAPTER

DIGITAL INSTRUMENTS

Ramp-type DVM

The principle of operation of the ramp-type DVM is based on the measurements of the time it takes for linear lamp voltage to rise from 0 V to the level of input voltage, or decrease from the level of the input voltage to zero. This interval of time is measured with an electronic time interval counter, and the count is displayed as a number of digits on electronic indicating tubes.

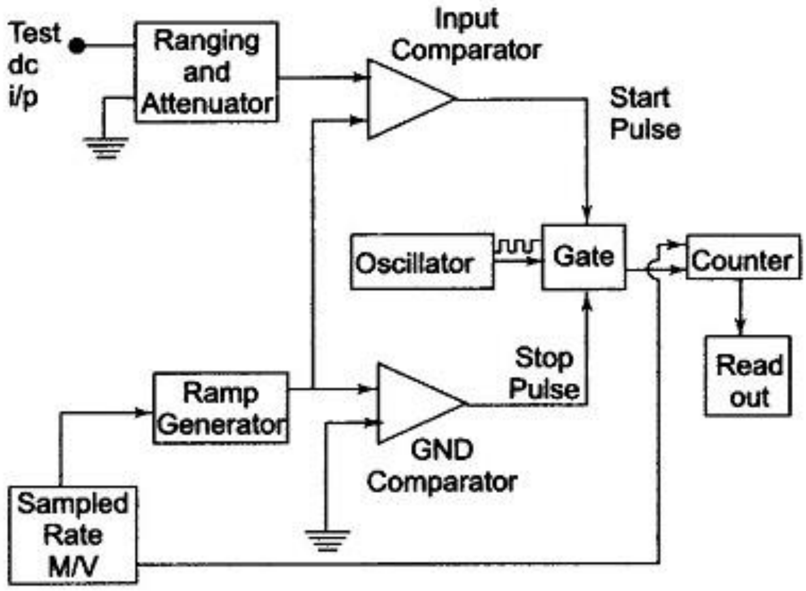


Fig. 5.2 ▬ Block Diagram of Ramp Type DVM

At the start of the measuring cycle, a ramp voltage is initiated; this voltage can be positive going or negative going. The negative going ramp, shown in the fig. is continuously compared with the unknown input-voltage. At the instant that the ramp voltage equals the unknown voltage , a coincidence circuit, comparator, generates a pulse which open a gate[see fig.].The ramp voltage continues to decrease with time until it finally reaches 0 V[or ground potential] and a second comparator generates an output pulses which closes the gate.

An oscillator generates clock pulses which are allowed to pass through the gate to a number of decade counting units [DCUs] which totalize the number of pulses passed through the gate.

The decimal number, displayed by the indicator tubes associated with the DCUs, is a measure of the magnitude of the input voltage.

The sample-rate multi-vibrator [MV] determines the rate at high the measurement cycle are initiated. The sample-rate circuit provides an initiating pulse for the ramp generator to start its next ramp voltage. At the same time ,a reset pulse is generated which returns all the DCUs o their zero state, removing the display momentarily from the indicator tubes.

Characteristics of Digital Meters

Following are the few specifications which characterise digital meters:

1. Resolution- It is defined as the number of digit positions or simply the number of digits used in a meter.

If a number of full digits is n, then resolution,

R=1/10n

For n=4 R=1/104 =0.0001 or 0.01%.

A three-digit display on the digital meter for 0-1 V range will be able to indicate from 000 to 999mV, with smallest increment (resolution) of 1mV.

2. Sensitivity-

It is the smallest change in input which a digital meter is able to detect. Thus, it is the full-scale value of the lowest voltage range multiplied by the resolution of the meter .In other words,

Sensitivity,

S=(fs) min* R

Where,

(fs)=Lowest full-scale value of digital meter, and

R=Resolution is decimal.

DIGITAL FREQUENCY METER

Principle of Operation Frequency is one of the most basic parameters in electronic, it has very close relationship with many measurement schemes of electric parameter and measurement results, so the frequency measurement becomes more important, it has been widely used in aerospace, electronics, measurement and control field .

Digital frequency meter composed by oscillator, frequency dividers, shaping circuit, counting & decoding IC circuit. Oscillation circuit generates frequency signal, we can get a 0.5HZ signal when the frequency signal through frequency divider. Diagram of digital frequency meter as shown

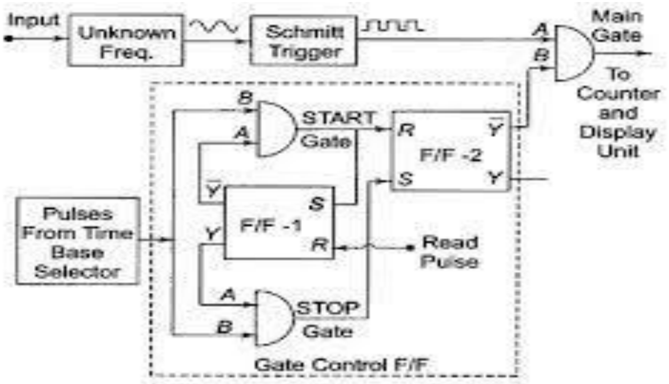


Fig. 6.6 ▬ Basic Circuit for Measurement of Frequency Showing Gate Control F/F

Design and simulation of digital frequency meter :

Two types are circuits being used in the frequency meter. Oscillator circuit and frequency division circuit (1) Oscillator circuit

Oscillator is the core of timer, stability and the accuracy of osci accuracy[9-10], using IC 555 timing and RC constitute the os 500HZ, (2) Frequency division circuit : Oscillator produce a rectangle wave is 500Hz, using frequency dividers to get 0.5Hz timer signal, 74LS90 is a 2 dividers which composed by three 74LS90 can divided 500HZ rectangular pulse into 0.5 HZ.

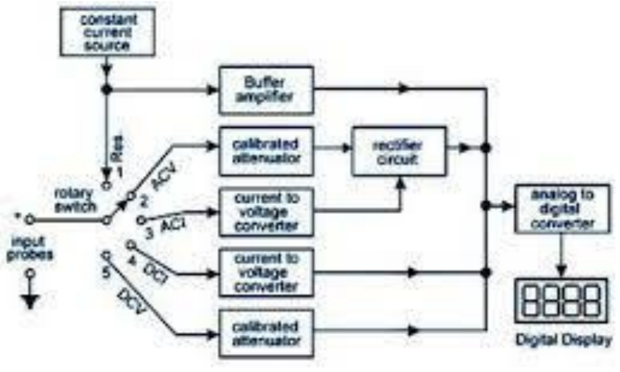
DIGITAL MULTIMETER

A Digital multi meter offers increased versatility due to its additional capability to measure A.C voltage and current, D.C voltage and current, resistance. The FIG. Shows the block diagram of a digital multimeter (DMM)

- In the “A.C voltage mode” ,the applied input is fed through a calibrated/ compensated attenuator ,to a precision fu;; wave rectifier circuit followed by
- The resulting D.C fed to ADC and the subsequent display system.
- Fr current measurements the drop across an internal calibrated shunt is measured ,directly By the ADC in the “D.C current mode” , and after A.C to D. C conversion i current mode”. This drop is often in the range of 200 mv.
- Due to lack of precision in the A.C general of the order of 0.2 to 0.5%. In addition , the measurement range is often limited to about 50 Hz at the lower frequency end due to the ripple in the rectified signal becoming a non negligible percentage of the display and hence in fluctuation of the displayed number.
- In the resistance range the multi meter operates by measuring the voltage ac connected resistance, resulting from a current forced through it from a calibrated internal current source. Oscillator is the core of timer, stability and the accuracy of oscillator frequency determine the timing and RC constitute the oscillator which frequency is Oscillator produce a rectangle wave is 500Hz, using frequency dividers to get 0.5Hz timer signal, 74LS90 is a 2-5 -10 decimal additions counter, use frequency hree 74LS90 can divided 500HZ rectangular pulse into 0.5 HZ.

DIGITAL MULTIMETER

A Digital multi meter offers increased versatility due to its additional capability to measure A.C D.C voltage and current, resistance. The FIG. Shows the block diagram of a digital multimeter (DMM) In the “A.C voltage mode” ,the applied input is fed through a calibrated/ compensated attenuator ,to a precision fu;; wave rectifier circuit followed by a ripple reduction filter The resulting D.C fed to ADC and the subsequent display system. Fr current measurements the drop across an internal calibrated shunt is measure , directly By the ADC in the “D.C current mode” , and after A.C to D. C conversion i current mode”.



DMM

This drop is often in the range of 200 mv. Due to lack of precision in the A.C –D.C conversions, the accuracy in the A.C range is in general of the order of 0.2 to 0.5%. In addition , the measurement range is often limited to out 50 Hz at the lower frequency end due to the ripple in the rectified signal becoming a non negligible percentage of the display and hence in fluctuation of the displayed number.

In the resistance range the multimeter operates by measuring the voltage ac connected resistance ,resulting from a current forced through it from a calibrated internal [Page 21] llator frequency determine the timer oscillator which frequency is Oscillator produce a rectangle wave is 500Hz, using frequency s counter, use frequency hree 74LS90 can divided 500HZ rectangular pulse into 0.5 HZ.

A Digital multi meter offers increased versatility due to its additional capability to measure A.C In the “A.C voltage mode” ,the applied input is fed through a calibrated/ compensated a ripple reduction filter Fr current measurements the drop across an internal calibrated shunt is measured ,directly By the ADC in the “D.C current mode” , and after A.C to D. C conversion in the “

A.C D.C conversions, the accuracy in the A.C range is in general of the order of 0.2 to 0.5%. In addition , the measurement range is often limited to out 50 Hz at the lower frequency end due to the ripple in the rectified signal becoming a non negligible percentage of the display and hence in fluctuation of the displayed number. In the resistance range the multi meter operates by measuring the voltage across the externally

- The accuracy of resistance measurement is of the order of 0.1 to0.5% depending on the accuracy and stability of the internal current sources the accuracy may be proper in the highest range which is often about 10 to 20 MΩ. In the lowest range the full scale may be 200Ω with a resolution of about 0.01Ω for a digital multi meter. Measurement of Time (Period Measurement)

- In some cases it is necessary to measure the time period rather than the frequency. This is especially true in the measurement of frequency in the low frequency range. To obtain good accuracy at low frequency, we should take measurements of the period, rather than make direct frequency measurements. The circuit used for measuring frequency (Fig.) can be used for the measurement of time period if the counted signal and gating signal are interchanged.

- Figure shows the circuit for measurement of time period. The gating signal is derived from the unknown input signal, which now controls the enabling and disabling of the main gate. The number of pulses which occur during one period of the unknown signal are counted and displayed by the decade counting assemblies. The only disadvantage is that for measuring the frequency in the low frequency range, the operator has to calculate the frequency from the time by using the equation/= l/T.

DIGITAL TACHOMETER

The technique employed in measuring the speed of a rotating shaft is similar to the technique used in a conventional frequency counter, except that the selection of the gate period is in accordance with the rpm calibration.

Let us assume, that the rpm of a rotating shaft is R. Let P be the number of pulses produced by the pick up for one revolution of the shaft. Therefore, in one minute the number of pulses from the pick up is R x P.

Then, the-frequency of the signal from the pick up is (R x P)/60. Now, if the gate period is G s the pulses counted are (R x P x G)/60. In order to get the direct reading in rpm, the number of pulses to be counted by the counter is R. So we select the gate period as 60/ P, and the counter counts (Rx P x 60)/ 60P = R pulses and we can read the rpm of the rotating shaft directly. S

So, the relation between the gate period and the number of pulses produced by the pickup is G = 60/P. If we fix the gate period as one second (G = 1 s), then the revolution pickup must be capable of producing 60 pulses per revolution. Figure shows a schematic diagram of a digital tachometer

AUTOMATION

Automatic Polarity Indication :The polarity indication is generally obtained from the information in the ADC. For integrating ADCs, only the polarity of the integrated signal is of importance. The polarity should thus be measured at the very end of the integration period (see Fig. 6.21). As the length of the integration period is determined by counting a number of clock pulses, it is logical to use the last count or some of the last counts to start the polarity measurement. The output of the integrator is then used to set the polarity flip-flop, the output of which is stored in memory until the next measurement is made.

2. Automatic Ranging:

The object of automatic ranging is to get a reading with optimum resolution under all circumstances (e.g. 170 m V should be displayed as 170.0 and not as 0.170). Let us take the example of a 3Yz digit display, i.e. one with a maximum reading of 1999. This maximum means that any higher value must be reduced by a factor of 10 before it can be displayed (e.g. 201 m Vas 0201). On the other hand, any value below 0200 can be displayed with one decade more resolution (e.g. 195 mV as 195.0). In other words, if the display does not reach a value of 0200, the instrument should automatically be switched to a more sensitive range, and if a value of higher than 1999 is offered, the next less sensitive range must be selected.