ATME COLLEGE OF ENGINEERING

13th KM Stone, Bannur Road, Mysore - 570 028

DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGINEERING

NOTES

SUBJECT: **ELECTRICAL AND ELECTRONIC MEASUREMENTS**

SUB CODE: **BEE306B**
SEMESTER**: 111**

Electrical Measurements and Instrumentation		Semester	III
Course Code	BEE306B	CIE Marks	50
Teaching Hours/Week (L: T:P: S)	3:0:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03
Examination nature (SEE)	Theory		

Course objectives:

- To understand the significance and methods of Measurements, elements of generalised measurement system and errors in measurements.
- To measure resistance, inductance, capacitance by use of different bridges.
- To study the construction, working and characteristics of various instrument transformers.
- To have the working knowledge of electronic instruments and display devices.

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

1. Lecturer method (L) needs not to be only traditional lecture method, but alternative effective teaching methods could be adopted to attain the outcomes.
2. Use of Video/Animation to explain functioning of various concepts.
3. Encourage collaborative (Group Learning) Learning in the class.
4. Ask at least three HOT (Higher order Thinking) questions in the class, which promotes critical thinking.
5. Adopt Problem Based Learning (PBL), which fosters students' Analytical skills, develop design thinking skills such as the ability to design, evaluate, generalize, and analyze information rather than simply recall it.
6. Introduce Topics in manifold representations.
7. Show the different ways to solve the same problem with different circuits/logic and encourage the students to come up with their own creative ways to solve them.
8. Discuss how every concept can be applied to the real world-and when that's possible, it helps improve the students' understanding.

Module-1

Measurements and Measurement systems: Introduction, significance and methods of Measurements, Instruments and measurement systems, Mechanical, electrical and electronic instruments. Classification of instruments. Functions and applications of Measurement systems. Types of Instrumentation systems, information and signal processing. Elements of generalised measurement system. Input-output configurations of measuring instruments and measurement systems. Methods of correction for interfering and modifying inputs, errors in measurements, Accuracy and precision.

Module-2

Measurement of Resistance: Wheatstone's bridge, sensitivity, limitations. Kelvin's double bridge. Earth resistance measurement by fall of potential method and by using Megger.

Measurement of Inductance and Capacitance: Sources and detectors, Maxwell's inductance and capacitance bridge, Hay's bridge, Anderson's bridge, Desauty's bridge, Schering bridge. Shielding of bridges. (Derivations and Numerical as applicable).

Module-3

Instrument Transformers: Introduction, Use of Instrument transformers. Burden on Instrument transformer.

Current transformer (CT): Relationships in CT, Errors in CT, characteristics of CT, causes and reduction of errors in CT, Construction and theory of CT.

Potential transformer (PT): Difference between CT and PT, Relationships in PT, Errors in PT, characteristics of PT, reduction of errors in PT.

Magnetic measurements: Introduction, measurement of flux/ flux density, magnetising force and leakage factor.

Module-4

Electronic and Digital Instruments: Introduction. Essentials of electronic instruments, Advantages of electronic instruments. True RMS reading voltmeter. Electronic multimeters. Digital voltmeters (DVM) - Ramp type DVM, Integrating type DVM and Successive - approximation DVM. Q meter. Principle of working of electronic energy meter (with block diagram), extra features offered by present day meters and their significance in billing.

Module-5

Display Devices: Introduction, character formats, segment displays, Dot matrix displays, Bar graph displays. Cathode ray tubes, Light emitting diodes, Liquid crystal displays, Nixes, Incandescent, Fluorescent, Liquid vapour and Visual displays.

Recording Devices: Introduction, Strip chart recorders, Galvanometer recorders, Null balance recorders, Potentiometer type recorders, Bridge type recorders, LVDT type recorders, Circular chart and xy recorders. Digital tape recording, Ultraviolet recorders. Electro Cardio Graph (ECG).

Course outcome (Course Skill Set)

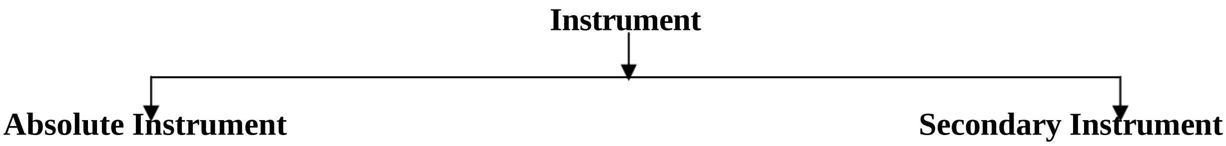
At the end of the course, the student will be able to :

1. Explain the significance and methods of Measurements, elements of generalised measurement system and errors in measurements.
2. Measure resistance, inductance and capacitance by different methods.
3. Explain the construction, working and characteristics of various instrument transformers.
4. Explain the working of different electronic instruments and display devices.

Module-1
Measurements and Measurement systems

1.1 Definition of instruments

An instrument is a device in which we can determine the magnitude or value of the quantity to be measured. The measuring quantity can be voltage, current, power and energy etc. Generally, instruments are classified in to two categories.



1.2 Absolute instrument

An absolute instrument determines the magnitude of the quantity to be measured in terms of the instrument parameter. This instrument is really used, because each time the value of the measuring quantities varies. So, we have to calculate the magnitude of the measuring quantity, analytically which is time consuming. These types of instruments are suitable for laboratory use. Example: Tangent galvanometer.

1.3 Secondary instrument

This instrument determines the value of the quantity to be measured directly. Generally these instruments are calibrated by comparing with another standard secondary instrument.

Examples of such instruments are voltmeter, ammeter and wattmeter etc. Practically secondary instruments are suitable for measurement.

Secondary instruments

Indicating instruments **Recording** **Integrating** **Electromechanically Indicating**

instruments

1.3.1 Indicating instrument

This instrument uses a dial and pointer to determine the value of measuring quantity. The pointer indication gives the magnitude of measuring quantity.

1.3.2 Recording instrument

This type of instruments records the magnitude of the quantity to be measured continuously over a specified period of time.

1.3.3 Integrating instrument

This type of instrument gives the total amount of the quantity to be measured over a specified period of time.

1.3.4 Electromechanical indicating instrument

For satisfactory operation electromechanical indicating instrument, three forces are necessary. They are

(a) Deflecting force

(b) Controlling force

(c)Damping force

1.4 Deflecting force

When there is no input signal to the instrument, the pointer will be at its zero position. To deflect the pointer from its zero position, a force is necessary which is known as deflecting force. A system which produces the deflecting force is known as a deflecting system. Generally a deflecting system converts an electrical signal to a mechanical force.

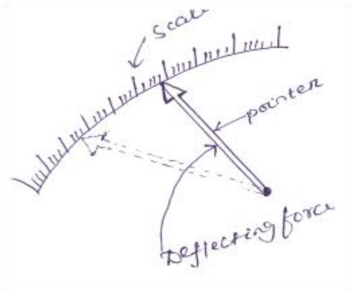
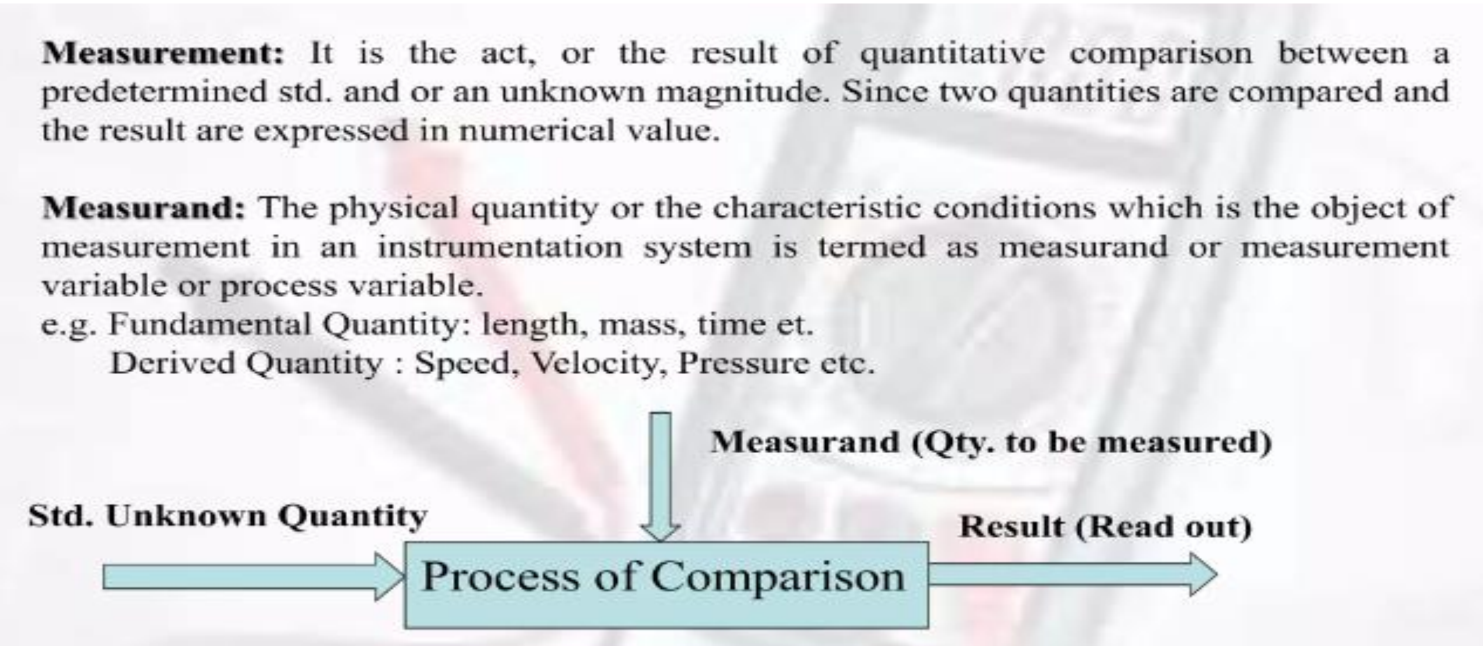


Fig. 1.1 Pointer scale



Basics Requirement :

- The Standard used for comparison purposes must be accurately defined and should be commonly accepted and
- The apparatus used and the method adopted must be provable.

Significance of Measurement

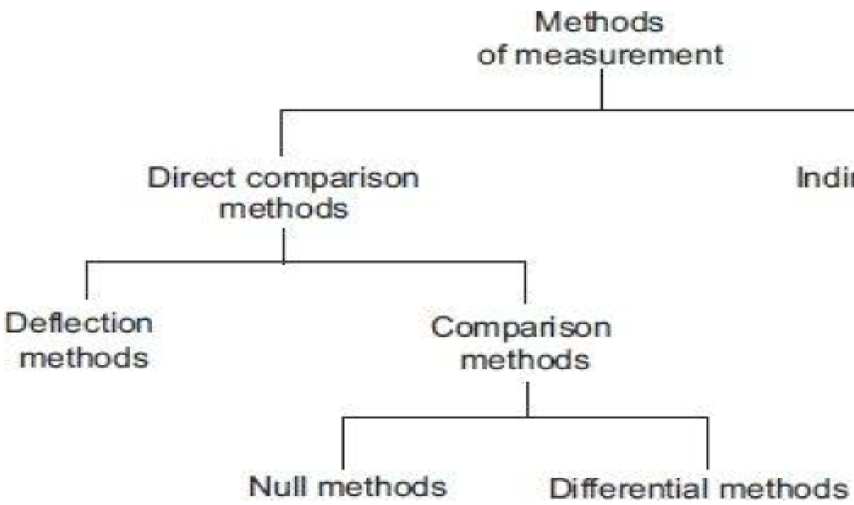
"When you can measure, what you are speaking and express it in numbers, you know something about and can express it in numbers, you know something about it, when you cannot express in it numbers in knowledge is of meagre and unsatisfactory kind" – Lord Kelvin

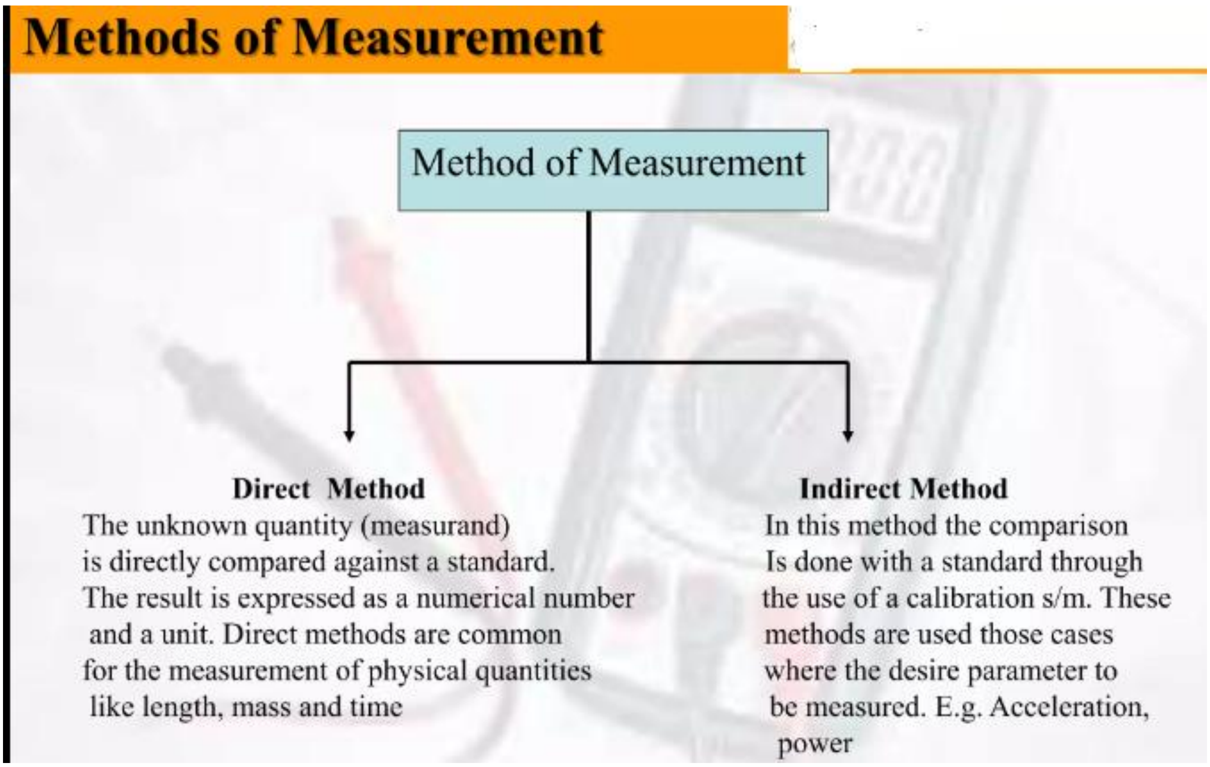
The measurement confirms the validity of a hypothesis and also add to it the understanding. This eventually leads to new discoveries that require new and sophisticated measuring techniques.

Through measurement a product can be designed or a process be operated with max. efficiency , minimum cost and with desired degree of reliability and maintainability

- Measurement helps us to compare unknown quantities with the known quantities.
- Measurement helps us make quantitative statements about how big, how long, how fast things are. Without measurement, the final product will be full of errors.
- Examples:- Speedometer is used to measure the speed of the vehicles.
- The Measurement , No doubt, confirm the validity of a hypothesis but also add to its understanding . This leads to new discoveries and it requires new techniques and need better Measurement tools.
- Economical design of equipment, Proper operation and maintenance of equipment require measurements because it plays a significant role in achieving goals and objectives of engineering and also it act as back data or feedback of information.

METHODS OF MEASUREMENT





Instrumentals and Measurement Systems:

4 main functions performed

Indicating Function: This function involves providing data related to the variable being measured. Various methods can be used in instruments and systems to achieve this objective. Typically, this data is acquired by observing the movement or displacement of a pointer on a measuring instrument.

Recording Function: Instrument makes a written record, usually on paper, of the value of the quantity under measurement against time or against some other variable, Ex HTST pasteurizer gives the instantaneous temperatures on a strip chart recorder.

Signal Processing: This function is performed to process and modify the measured signal to facilitate recording / control.

Controlling Function: This is one of the most important functions, especially in the food processing industries where the processing operations are required to be precisely controlled. In this case, the information is used by the instrument or the systems to control the original measured variable or quantity.

- Scientific instruments used three essential elements as our modern instruments these elements are

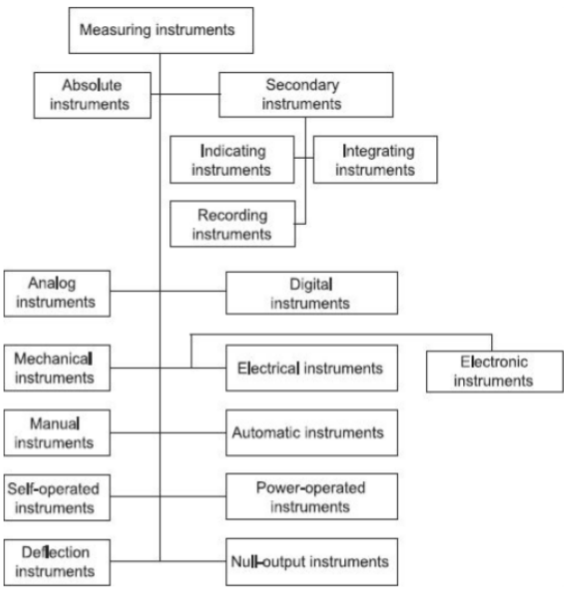
1. A detector
2. An intermediate transfer device
3. An indicator recorder or a storage device.

- The history of development of instruments encompasses three phases of instruments

1. Mechanical instrument
2. Electrical instrument

Electronics Instrument

CLASSIFICATION OF INSTRUMENTS



Mechanical instruments:

- The mechanical instruments are mainly used for measuring physical quantities.
- This instruments is suitable for measuring the static and stable conditions , because these instruments is unable to give the response to the dynamic condition or transient condition.
- These instruments have moving parts that are rigid, heavy and bulky, consequently have a large mass. Mass presents inertia problems hence these measurements cannot follow rapid changes (dynamic conditions).
- These instruments cause noise pollution.

Electrical Instruments :

- Electrical Instruments has quick response time and are more rapid compared to mechanical instruments.
- Unfortunately electrical system depends on mechanical meter movement as indicating devices and mechanical movement have some inertia and again they have limited time and frequency response.

Electronics Instruments:

- The need for rapid response and dynamic parameter monitoring has driven the continuous development of semiconductor devices and electronics instruments.
- The response time of semiconductor devices is only that electrons to electrons which have very small inertia.
- Electronics instruments are more reliable due to improvements in design and manufacturing processes of semiconductor devices.
- They are light, compact and have a high degree of reliability and power consumption is very small.
- With the help of transducer, Non- electrical quantity is converted into electrical form therin electronic instrument have a significant role.
- Electronic instrument helps in detection of electromagnetically produced signals like radio, video and microwaves.
- Electronics instruments have higher sensitivity , greater flexibility.
- This development has been essential in various fields and industries
- **Telecommunications, Medical Devices, Industrial Automation, Aerospace and Defense, Environmental Monitoring, Automotive Industry, Scientific Research**

Definition of instruments :
An instrument is a device in which we can determine the magnitude or value of the quantity to be measured. The measuring quantity can be voltage, current, power and energy etc.

Classification of instrument :

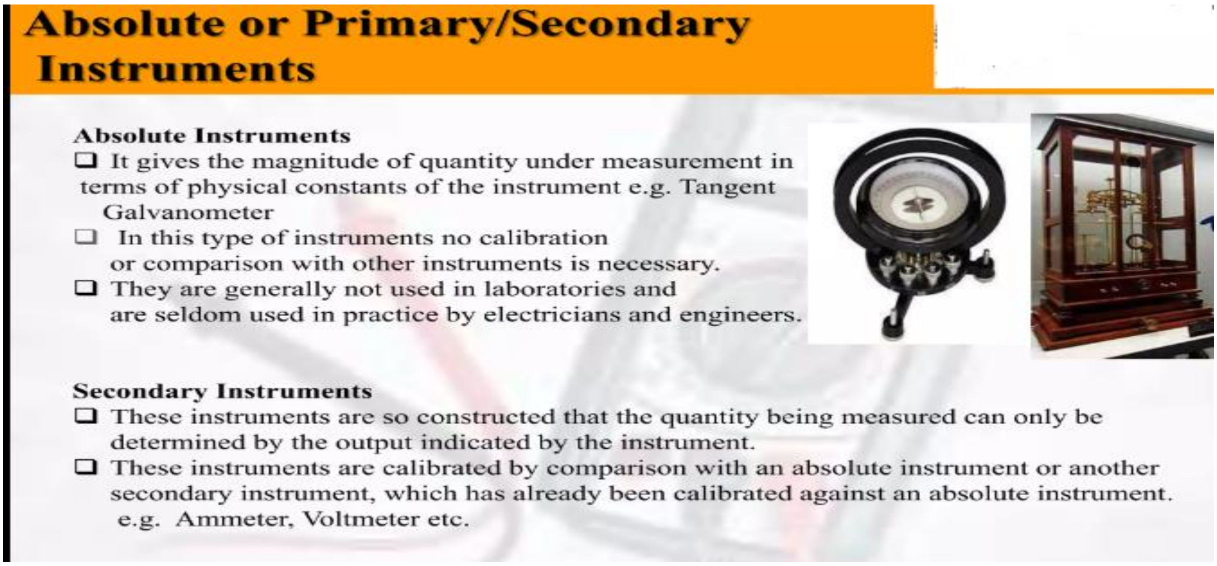
1.Absolute and Secondary instruments
2.Direct measuring and comparison instruments
3.Analog and Digital instruments
4. indicating, Recording, integrating and controlling instruments
5. Automatic and manual instruments
6.Active and passive instruments/Self and Power operated instruments
7.Deflection and Null type instruments
8.Mechanical/ Electrical and Electronics instruments

Absolute instrument:

An absolute instrument determines the magnitude of the quantity to be measured in terms of the instrument parameter. This instrument is really used, because each time the value of the measuring quantities varies. So we have to calculate the magnitude of the measuring quantity, analytically which is time consuming. These types of instruments are suitable for laboratory use. Example: Tangent galvanometer.

Secondary instrument:

This instrument determines the value of the quantity to be measured directly. Generally these instruments are calibrated by comparing with another standard secondary instrument. Examples of such instruments are voltmeter, ammeter and wattmeter etc. Practically secondary instruments are suitable for measurement.

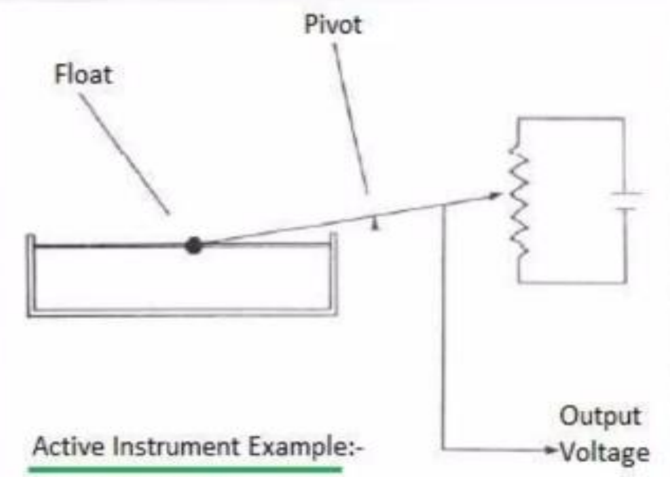


Direct measuring instruments: These instruments converts the energy of the measured quantity directly into energy that actuates the instrument and the value of the unknown quantity is measured or displayed or recorded directly Examples are Ammeter, Voltmeter, Watt meter etc.

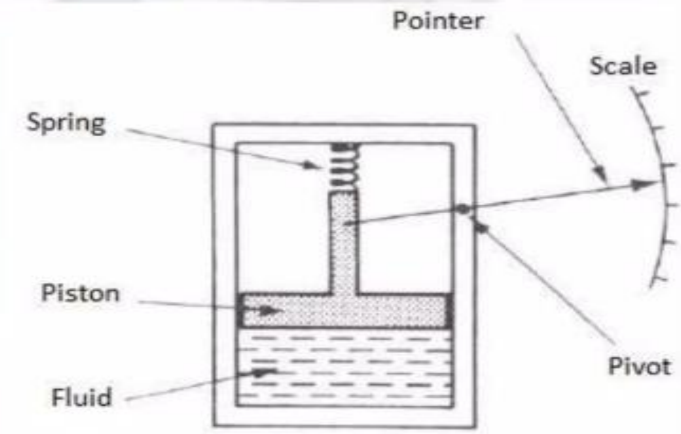
- **Comparison instruments:** These instruments measure the unknown quantity by comparison with a standard. Examples are dc and ac bridges and potentiometers. They are used when a higher accuracy of measurements is desired

Analogue Instruments: The signal of an analog unit vary in a continuous fashion and can take an infinite no. of values in a given range. E.g. ammeters, voltmeter, wrist watch , speedometer etc.

Digital instruments: Signals varying in discrete steps and taking on a finite no. of different values in a given range are digital signals e.gs timer on a score board, odometer of an automobile



Active Instrument Example:-
Petrol tank level indicator



Passive Instrument Example:-
Pressure Measuring Device

Deflection

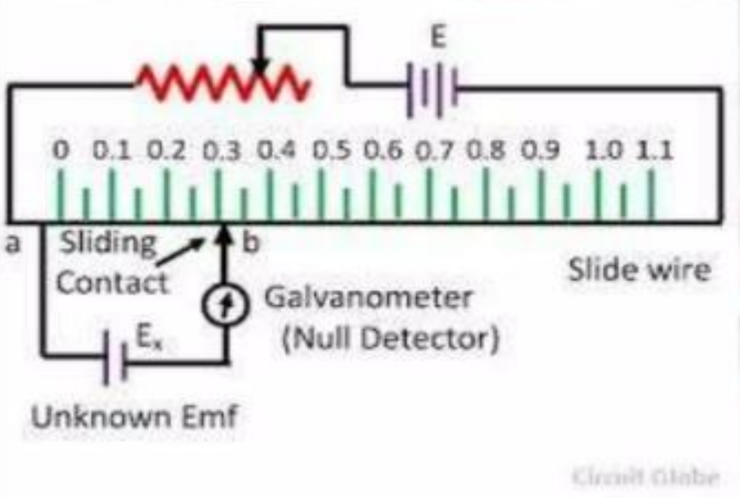
- Only one source of input reqd.
- Output reading is based on the deflection from the initial condition of the instrument
- The measurand value of the qty. depends on the calibration of the instrument

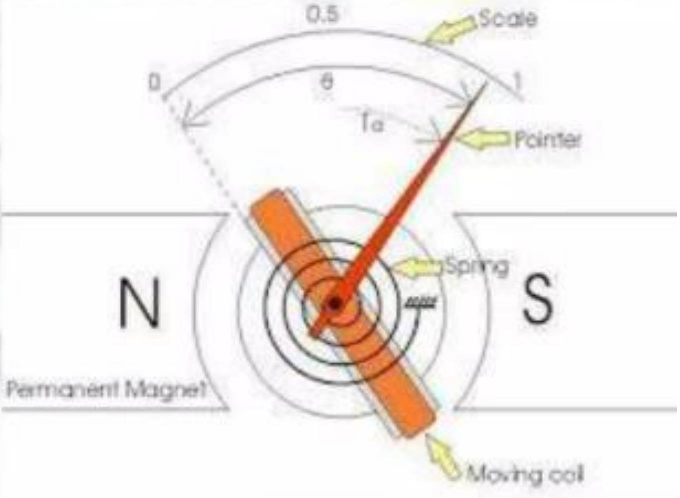
Null

Require two input- measurand and balance input

Must have feedback operation that compares the measurand with std. value

Most accurate and sensitive

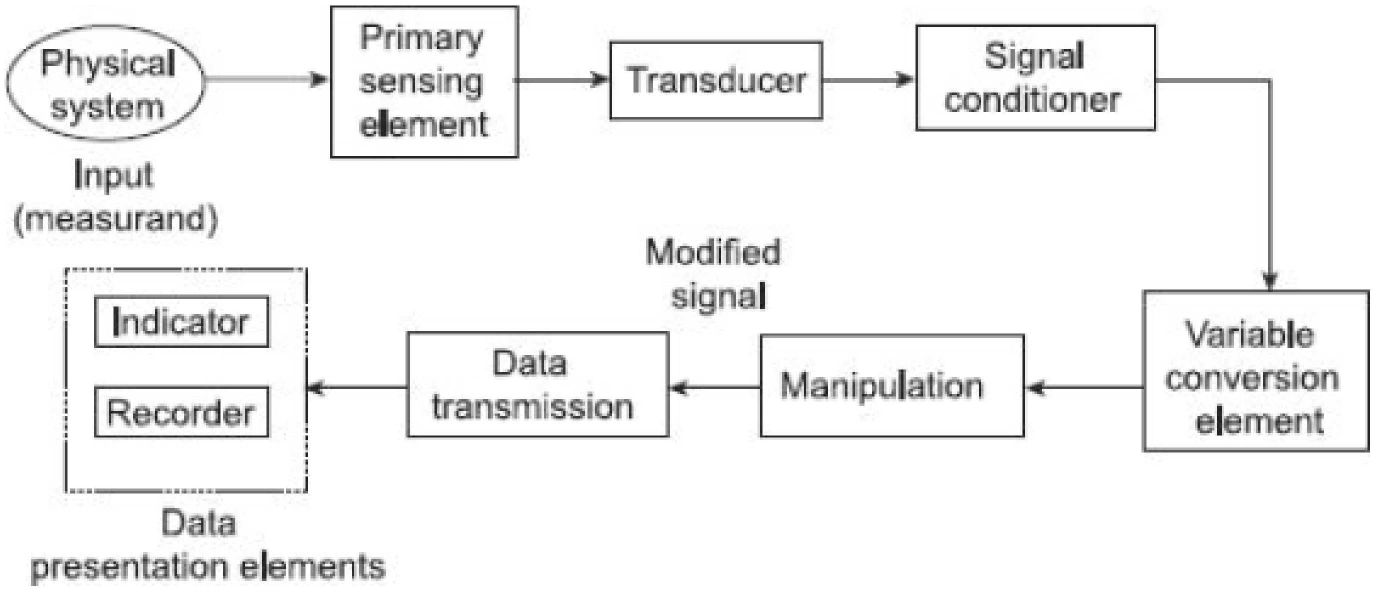




Essential Requirements of Indicating Instruments

1. **Deflecting torque (Td) :** Deflecting torque causes the moving system and pointer of the instrument to move from its zero position. Production of deflecting torque depends upon the type of indicating instrument and its principle of operation
2. **Controlling torque (Tc) :** Controlling torque limits the movement of pointer and ensures that the magnitude of deflection is unique and is always same for the given value of electrical quantity to be measured.

MEASUREMENT SYSTEM AND ITS ELEMENTS



Module-2

Measurement of resistance, inductance and capacitance

Introduction:

A bridge circuit in its simplest form consists of a network of four *resistance arms* forming a closed circuit. A source of current is applied to two opposi te junctions. The current detector is connected to other two junctions.

The bridge circuits use the comparison measurement methods and operate on null-indication principle. The bridge circuit compares the value of an unknown component with that of an accurately known standard component. Thus *the* accuracy depends on the bridge components and not on the null indicator. Hence high degree of accuracy can be obtained.

Advantages of Bridge Circuit:

The various advantages of the bridge circuit are,

1) The balance equation is independent of the magnitude of the input voltage or its source impedance. These quantities do not appear in the balance equation expression.

2) The measurement accuracy is high as the measurement is done by comparing the unknown value with the standard value.

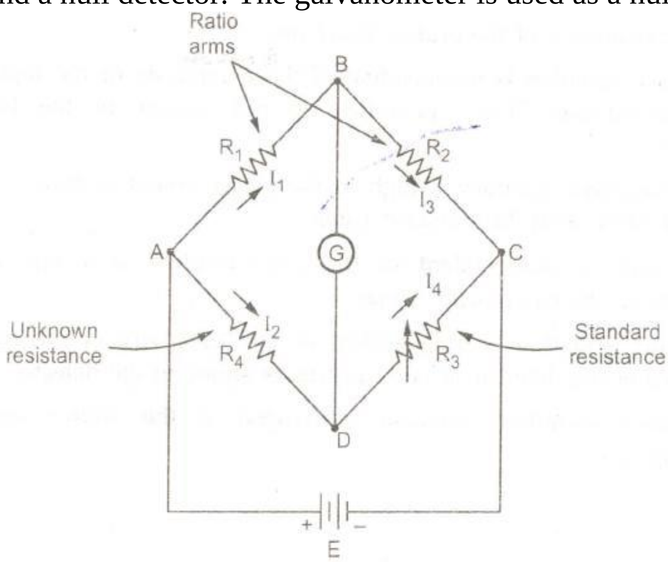
3) The accuracy is independent of the characteristics of a null detector and is dependent on the component values.

4) The balance equation is independent of the sensitivity of the null detector, the impedance of the detector or any impedance shunting the detector.

5) The balance condition remains unchanged if the source and detector are interchanged.

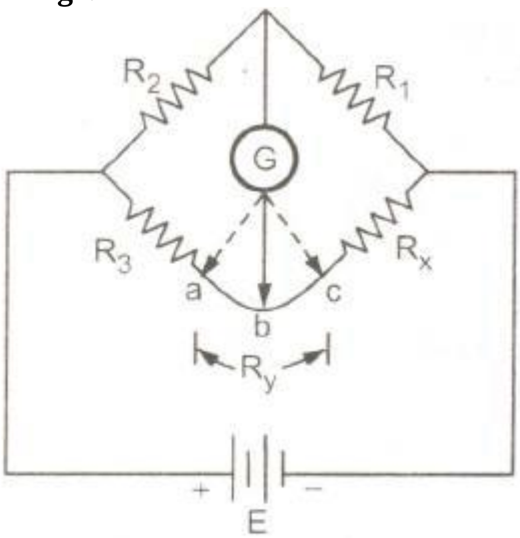
Wheatstone's bridge:

The bridge consists of four resistive arms together with a source of e.m.f. and a null detector. The galvanometer is used as a null detector.



The arms consisting the resistances R] and R2 are called ratio arms. The arm consisting the standard known resistance R3 is called standard arm. The resistance R4 is the unknown resistance to be measured. The battery is connected between A and C while galvanometer is connected between Band D.

Kelvin bridge:



In the Wheatstone bridge, the bridge contact and lead resistance causes significant error, while measuring low resistances. Thus for measuring the values of resistance below 1 -n, the modified form of Wh~tstone bridge is used, known as Kelvin bridge. The consideration of the effect of contact and lead resistances is the basic aim of the Kelvin bridge.

The resistance Rv represents the resistance of the connecting leads from R., to R,. The resistance Rx is the unknown resistance to be measured.

\ The galvanometer can be connected to either terminal a, b or terminal c. When it is connected to a, the lead resistance Ry gets added to Rx hence the value measured by the bridge, indicates much higher value of Rx.

If the galvanometer is connected to terminal c, then Ry gets added to R3. This results in the measurement of Rx much lower than the actual value.

The point b is in between the points a and c, in such a way that the ratio of the resistance from c to b and that from a to b is equal to the ratio of R] and R2.

$$\frac{R_{cb}}{R_{ab}} = \frac{R_1}{R_2}$$

A.C. Bridges:

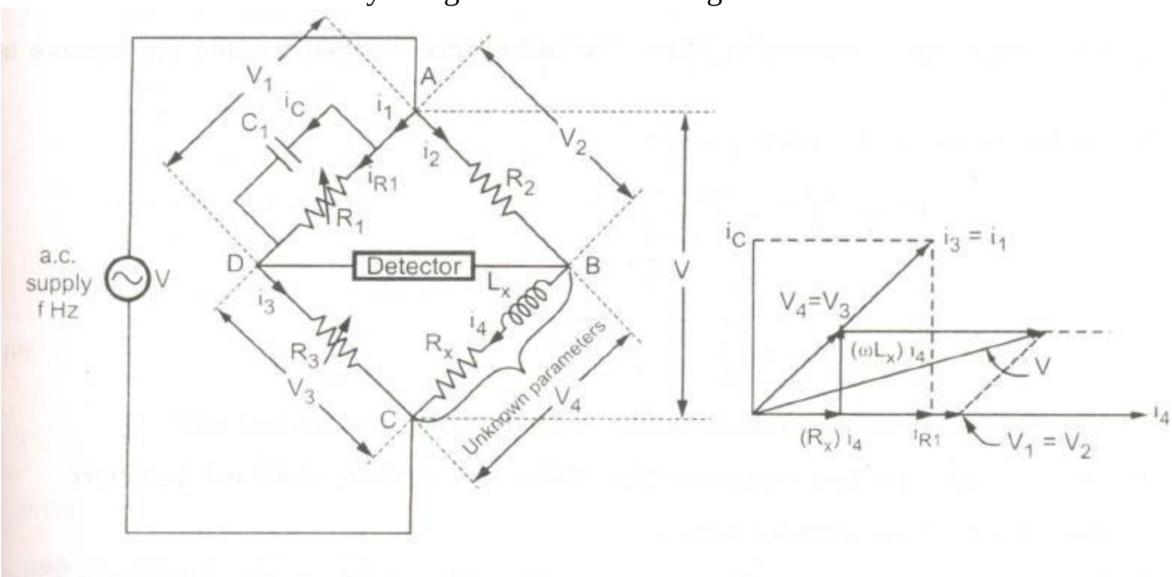
An a.c. bridge in its basic form consists of four arms, a source of excitation and a balance detector. Each arm consists of an impedance. The source is an a.c. supply which supplies a.c. voltage at the required frequency. For high frequencies, the electronic oscillators are used as the source. The balance detectors commonly used for a.c. bridge are head phones, tunable amplifier circuits or vibration galvanometers. The headphones are used as detectors at the frequencies of 250 Hz to 3 to 4 kHz. While working with single frequency a tuned detector is the most sensitive detector. The vibration galvanometers are useful for low audio frequency range from 5 Hz to 1000 Hz but are commonly used below 200 Hz. Tunable amplifier detectors are used for frequency range of 10 Hz to 100 Hz.

Hay’s Bridge:

In the capacitance comparison bridge the ratio arms are resistive in nature. The impedance Z 3 consists of the· known standard capacitor C3 in series with the resistance R3. The resistance R3 is variable, used to balance the bridge. The impedance Z4 consists of the unknown capacitor Cx and its small leakage resistance Rx.

Maxwell's Bridge :

Maxwell's bridge can be used to measure inductance by comparison either with a variable standard self inductance or with a standard variable capacitance. These two measurements can be done by using the Maxwell's bridge in two different forms.



(a) Circuit diagram (b) Phasor diagram

Maxwell's inductance capacitance bridge

Methods of Measurement of Earth Resistance

Fall of Potential Method

Fig below shows the circuit diagram used for the measurement of earth resistance by fall of potential method. E is the earth electrode. The electrode Q is the auxillary electrode. The current I is passed through the electrodes E & Q with the help of external battery E. another auxillary electrode P is introduced in between the electrodes E & Q. the voltage between the electrodes E & P is measured with the help of voltmeter.

Thus if the distance of electrode P is changed from electrode E electrode Q, the electrode P experiences changing potential near the electrodes while a constant potential between the electrodes E & Q but away from the electrodes from Q.

The potential rises near the electrodes E & Q due to higher current density in the proximity of the electrodes. By measuring the potential between the electrodes E & P as Vep, the earth resistance can be obtained as

$$R_E = V_{EP} / I$$

Shielding and grounding of bridges

This is one way of reducing the effect of stary capacitances. But this technioque does not eliminate the stray capacitances but makes them constsnt invalue and hence they can be compensated.

One very effective and popular methode of eliminating the stray capacitances and the capacitances between the bridges arms is using a ground connection called Wagner Ground connection.

Questions from Question Paper:

1. Explain maxwell's bridge?June/July2009
2. Explain kelvin's bridge? Dec/Jan2008, Jan/ Feb 2012
3. Explain the importance of Wheatstone bridge? May/June2010
4. Explain the Capacitance Comparison Bridge? Dec/Jan2010
5. Explain the Maxwell's bridge?June/July 2009
6. Explain the Wagner's earth connection? Dec/Jan08, Jan/ Feb 2012
7. Derive the balance equations of the Schering bridge circuit configuration used for measurement of capacitances and hence derive at the expression for loss angle of the test capacitor. Draw the phasor diagram at balance.
   Jan/Feb-2004, July/Aug 2004, Jan/ Feb- 2008
8. Write a short note on the Wagner earthing device
   July/Aug-2004/2010,Jan/Feb-2011
9. Derive the expression for the measurement of capacitance and loss angle of a lossy capacitor using Schering bridge. Draw the phasor diagram at balance condition. What modifications are introduced when the bridge is used at high voltages Jan/Feb-2005, July/Aug 2004
10. Write briefly on the significance of shields used in ac bridge circuit. Hence discuss on the shielding of resistors and capacitors of the circuit
    July/Aug 2005, Jan/ Feb 2005
11. Draw a neat sketch to explain the theory and measurement of unknown inductance and resistance by Anderson bridge. What is type of null detector used in this bridge? What are the sources of errors? Draw phasor diagram at balance
    July/Aug 2006, Jan/ Feb 2006, Jan/ Feb 2012
12. Write short notes on source and detectors July/Aug 2008, Jan/ Feb 2007

Module-3

Instrument Transformers:

Instrument Transformers

They are divided into two types

- Current transformers
- Potential transformers

Current transformer

CT is the one which is to be measure a large current in ckt using low range ammeter. The primary winding of CT which has few no of turns is connected in series with load. The secondary of transformer is made up of large number of turns. This is connected to the coil of normal range ammeter, which is usually rated for 5A.

Potential Transformer

P.T. is the one which is used to measure a large voltage using a low range voltmeter. The primary winding consists of large number of turns while secondary has less number of turns. The primary is connected across high voltage line while secondary is connected to low range voltmeter coil.

The high voltage Vp being measured is given by, $V_p = nV_s$

Where, $n = N_p/N_s$ = turns ratio\

Why secondary of C.T. should not be open?

It is very important that secondary of C.T. should not be kept open. If it is left open, then current through secondary becomes zero. Hence, the ampere turns produced by secondary which generally oppose primary ampere turns becomes zero. As there is no counter m.m.f., unopposed primary mmf produces high flux in the core. This produces excessive core loss, heating the core beyond limits. Similarly heavy emf's will be induced on the primary and secondary side. This may damage the insulation of winding and this is danger from operator point of view as well Hence, never open secondary winding ckt of a CT, while its primary winding is energized.

3.5. Ratios of instrument transformers

The various ratios defined for instrument transformers are

Actual ratio® :

The actual transformation ratio is defined as the ratio of the magnitude of actual primary phasor to the corresponding magnitude of actual secondary phasor

C.T. R = magnitude of actual primary current / magnitude of actual sec. current

P.T. R = magnitude of actual primary voltage / magnitude of actual sec.voltage

Nominal ratio (Kn)

The nominal ratio is defined as the ratio of rated pri quantity to rated sec.quantity, either current or voltage

C.T. Kn = rated pri.current / rated sec. current

P.T., Kn = rated pri.voltage/ rated sec. voltage

Turns ratio(n)

C.T. , n = no.of turns of sec. winding / no. of turns of primary winding

P.T., n = no. of turns of primary winding / no. of turns of sec. winding

<u>3.5.1 Burden of an instrument transformer</u>

The permissible load across sec. winding expressed in volt amperes and the rated sec. winding , voltage or current such that errors do not exceed the limits is called burden of an instrument transformer.

Total sec. winding burden = (sec. winding induced voltage)^2 / total impedance of sec. ckt including load and winding

Derivation of actual ratio R

Consider triangle BAC as shown in small section where

$BC / AC = \sin(90-\delta-\alpha)$

$BC = AC \sin(90-\delta-\alpha)$

$BC = AC \cos(\delta+\alpha)$

$AB / AC = \cos(90-\delta-\alpha)$

$AB = AC \cos(90-\delta-\alpha)$

$AB = AC \cos(90-(\delta+\alpha))$

$AB = AC \sin(\delta+\alpha)$

Also,

$OC^2 = OB^2 + BC^2$

$IP^2 = (OA + AB)^2 + BC^2$

$Ip^2 = [nIs + I_0 \sin(\delta+\alpha)]^2 + I_0 \cos(\delta+\alpha)]^2$

$= nIs^2 + 2nIs I^0 \sin(\delta+\alpha) + I_0{}^2 \sin^2(\delta+\alpha) + I^{0\,2} \cos^2(\delta+\alpha)]$

$Ip^2 = nIs^2 + 2nIs\ {}_0 \sin(\delta+\alpha) + I_0{}^2$

I

$Ip = \sqrt{} nIs^2 + 2nIs I^0 \sin(\delta+\alpha) + I_0{}^2$

$R = Ip / Is = \sqrt{} nIs^2 + 2nIsI_0 \sin(\delta+\alpha) + I_0{}^2 \sin^2(\delta+\alpha)$

$\sqrt{}[nIs + I_0 \sin(\delta+\alpha)]^2 / Is$

$nIs + I_0 \sin(\delta+\alpha) / Is$

$n + I_{0/} Is \sin(\delta+\alpha)$

$n + I_{0/} Is (\sin\delta .\cos\alpha + \cos\delta \sin\alpha)$

<u>$R = n + I_m \sin\delta\ Ic.\cos\delta / Is$</u>

<u>Errors in C.T.</u>

There are 2 types os errors in instrument transformer . They are

- Ratio error
- Phase angle error

Ratio error

The ratio error is defined as %ratio error = nominal ratio – actual ratio / actual ratio *100

Ratio error = Kn – R /R *100

Phase angle error

The phase angle error is given by $\theta = 180 / \pi$ [$\underline{I_m \cos\delta \;\; - Ic.\sin\delta}$ / nIs]

Question paper Problems

1. Design a multirange dc milliammeter with a basic meter having a resistance 75Ω and full scale deflection for the current of 2 mA. The required ranges are 0-10mA, 0-50mA, 0-100mA\

Rm = 75 Ω, Im = 2mA

Rsh = = Rm / I/Im – 1
75 / 10/2 – 1 = 75/5-1 = 18.75 Ω

Rm = 75 / 50/2 – 1 = 75/25-1 = 3.125 Ω
75 / 100/2 – 1 = 75/49 = 1.53 Ω

2. A moving coil meter takes 50mA to produce fullscale deflection , the p.d.across its terminals be 75mV. Suggest a suitable scheme for using the instrument as a voltmeter reading 0-100V and as an ammeter reading 0-50A **Jan/ Feb 2012**

As an ammeter
V = IR
Rm = V/Im = 5 Ω

Rsh = Rm / I/Im – 1 = 1.501m Ω

As an voltmeter
Rs = V/Im - Rm = 6.661 kΩ

3. A c.t. has a single turn primary and 400 secondary turns. The magnetizing current is 90A while coreloss current is 40A. secondary ckt phase angle is 28. calculate the actual primary current and ratio error when secondary current carries 5A current

Ip = nIs
Ip = (Ns / Np) . Is

% ratio = Kn – R / R * 100

n = Ns / Np = 400

$R = n + I_m \sin\delta \ Ic.\cos\delta / Is$

$= 400 + \underline{90\sin28 + 40\cos28} / 5$

$= 415.513$

%ratio error = 400 – 415.513/415.513 *100 = -3.733%

I p = nIs

Ip = Ns/Np(5) = 400(5) = 2000A

R = Ip /Is

Ip = RIs = 415.513(5) = 2077.57A

4. At its rated load of 25VA, a 10/5 current transformer has an ironloss of 0.2W and magnetizing current of 1.5A. calculate its ratio error and phase angle when supplying rated o/p to a meter having a ratio of resistance to reactance of 5

% ratio = Kn – R / R * 100

$R = n + I_m \sin\delta \ Ic.\cos\delta / Is$

To find Ic

EpIp = 25VA

Ep = 25/100 = 0.25V

Ic = P /Ep = 0.2/0.25 = 0.8A

To find δ

δ = tan-1 Xs / Rs = 11.309

$R = n + I_m \sin\delta \ Ic.\cos\delta / Is$

20+ 1.5(0.1961) + 0.8(0.9805)/ 5 = 20.214

% ratio = Kn – R / R * 100

20-20.215/20.215 * 100 = -1.063%

To find θ $\theta = 180 / \pi \ [\underline{I_m \cos\delta \ - Ic.\sin\delta} / nIs]$

$= 180 / \pi \ [\underline{1.5(0.9805) \ - 0.8(0.1961)} / 20(5)]$

$= 0.752$

5. A C.T. of turns ratio 1:199is rated as 1000/5A, 25VA. The coreloss is 0.1Wand magnetizing current is 7.2A, under rated conditions . determine the phase angle and ratio errors for rated burden and rated sec.current 0.8p.f. lagging. Neglect winding resistance and reactance

$R = n + I_m \sin\delta \ Ic.\cos \delta / Is$

$199 + 7.2(0.6) + 4(0.8) / 5 = 200.504$

% ratio error = Kn – R / R * 100

= 200 – 200.504/20.504 * 100

= 0.251%

$\theta = 180 / \pi \ [\underline{I_m \cos\delta - Ic.\sin \delta} / nIs]$

$\theta = 180 / \pi \ [\underline{7.2(0.8) - 4(0.6)} / 199*5]$

$= 0.1934^{o}$

Descriptive Questions

1. Discuss briefly on the shunts and multipliers used for expression of meters in electrical measurements July/Aug 2005, Jan/ Feb 2004,2007
2. Write a note on the turns compensation used in instrument transformers July/Aug 2010, Jan/ Feb 2004, Jan/ Feb 2012
3. Discuss the various methods generally adopted for range extension of ammeters and voltmeters July/Aug 2004, July/Aug 2009
4. Briefly explain the design features of a CT July/Aug 2004
5. What are the disadvantages of shunts and multipliers used in measurement system Jan/ Feb 2005
6. What are the differences between CT and PT Jan/ Feb 2005,Jan/ Feb 20042007,2009,2010
7. What happens if the secondary of a CT is open circuited while the primary is carrying normal load current Jan/ Feb 2006
8. Explain clearly how shunts and multipliers are used to extend the range of instruments July/Aug 2007
9. Explain with circuit diagram Silsbee's method of testing of current transformer July/Aug 2007, Jan/ Feb 2012
10. Explain the principle of range extension of ammeter Jan/ Feb 2008
11. What are the advantages of instrument transformers July/Aug 2008, Jan/ Feb 2009,2011

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Module-4

Electronic and digital Instruments

Introduction:

The measurement of any quantity plays very important role not only in science but in all branches of engineering, medicine and in almost all the human day to day activities.

The technology of measurement is the base of advancement of science. The role of science and engineering is to discover the new phenomena, new relationships, the laws of nature

and to apply these discoveries to human as well as other scientific needs. The science and engineering is also responsible for the design of new equipments. The operation, control and the maintenance of such equipments and the processes is also one of the important functions of the science and engineering branches. All these activities are based on the proper measurement and recording of physical, chemical, mechanical, optical and many other types of parameters.

The measurement of a given parameter or quantity is the act or result of a quantitative comparison between a predefined standard and an unknown quantity to be measured. The major problem with any measuring instrument is the error. Hence, it is necessary to select the appropriate measuring instrument and measurement procedure which minimises the error. The measuring instrument should not affect the quantity to be measured.

An electronic instrument is the one which is based on electronic or electrical principles for its measurement function. The measurement of any electronic or electrical quantity or variable is termed as an electronic measurement.

Advantages of Electronic Measurement

The advantages of an electronic measurement are

1. Most of the quantities can be converted by transducers into the electrical or electronic signals.
2. An electrical or electronic signal can be amplified, filtered, multiplexed, sampled and measured.
3. The measurement can easily be obtained in or converted into digital form for automatic analysis and recording.

4 The measured signals can be transmitted over long distances with the help of cables or radio links, without any loss of information.

5. Many measurements can be carried either simultaneously or in rapid succession.
6. Electronic circuits can detect and amplify very weak signals and can measure the events of very short duration as well.
7. Electronic measurement makes possible to build analog and digital signals. The digital signals are very much required in computers. The modern development in science and technology are totally based on computers.
8. Higher sensitivity, low power consumption and a higher degree of reliability are the important features of electronic instruments and measurements. But, for any measurement, a well defined set of standards and calibration units is essential. This

chapter provides an introduction to different types of errors in measurement, the characteristics of an instrument and different calibration standards.

Voltmeters and multimeters

Basic meter:

A basic d.c. meter uses a motoring principle for its operation. It stntes that any current carrying coil placed in a magnetic field experiences a force, which is proportional to the magnitude of current passing through the coil. This movement of coil is called D'Arsonval movement and basic meter is called D'Arsonval galvanometer.

D.C instruments:

a) Using shunt resistance, d.c. current can be measured. The instrument is d.c. microammeter, milliammeter or ammeter.

b) Using series resistance called multiplier, d.c. voltage can be measured. The instrument is d.c. millivoltmeter, voltmeter or kilovoltmeter.

c) Using a battery and resistive network, resistance can be measured. The instrument is ohmmeter.

A.C instruments:

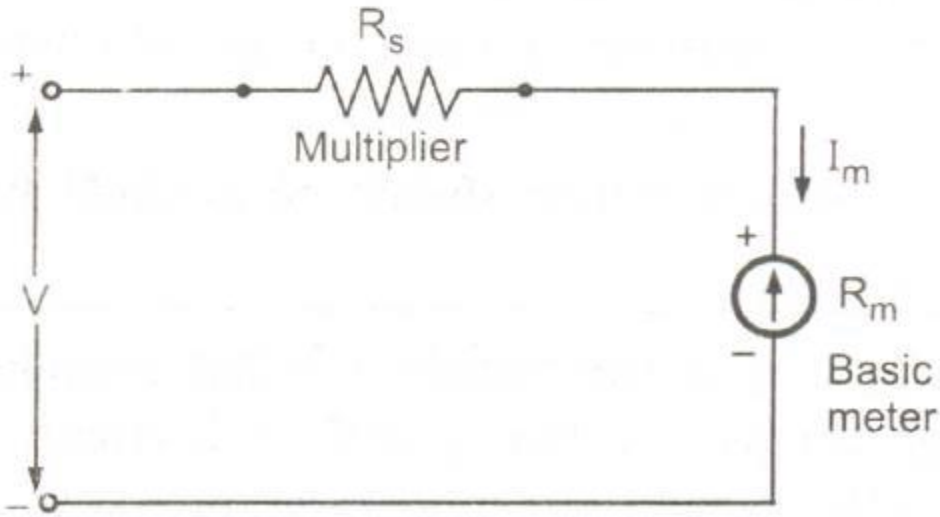
a) Using a rectifier, a.c. voltages can be measured, at power and audio frequencies. The instrument is a.c. voltmeter.

b) Using a thermocouple type meter radio frequency (RF) voltage or current can be measured.

c) Using a thermistor in a resistive bridge network, expanded scale for power line voltage can be obtained.

Basic voltmeter:

The basic d.c. voltmeter is nothing but a permanent magnet moving coil (PMMC) 0' Arsonval galvanometer. The resistance is required to be connected in series with the basic meter to use it as a voltmeter. This series resistance is called a **multiplier.** The main function of the multiplier is to limit the current through the basic meter so that the meter current does not exceed the full scale deflection value. The voltmeter measures the voltage across the two points of a circuit or a voltage across a circuit component. The basic d.c. voltmeter is shown in the Fig.



The voltmeter must be connected across the two points or a component, to measure the potential difference, with the proper polarity.
The multiplier resistance can be calculated as:

Let R_m = internal resistance of coil i.e. meter

R_s = series multiplier resistance

I_m = full scale deflection current

V = full range voltage to be measured

From Fig. 2.1, $\therefore V = I_m(R_m + R_s)$

$$\therefore V = I_m R_m + I_m R_s$$

$$\therefore I_m R_s = V - I_m R_m$$

$$\therefore \boxed{R_s = \frac{V}{I_m} - R_m}$$

Let v = drop across the basic meter = $I_m R_m$

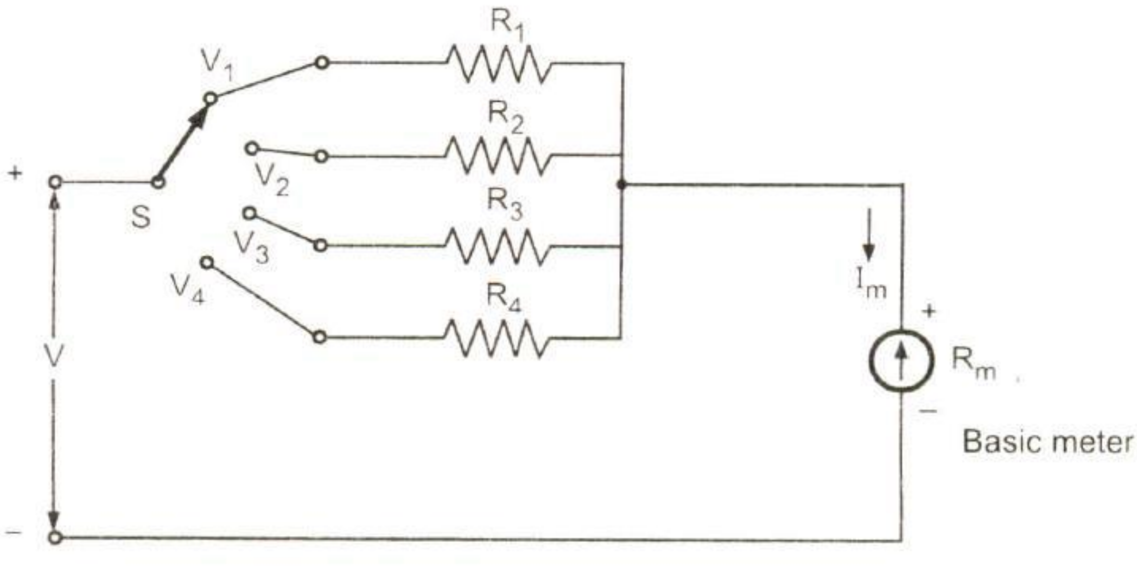
$\therefore$ m = multiplying factor = $\frac{V}{v}$

$$= \frac{I_m (R_m + R_s)}{I_m R_m}$$

$$m = 1 + \frac{R_s}{R_m}$$

Multirange voltmeters:

The range of the basic d.c. voltmeter can be extended by using number of multipliers clnd a selector switch. Such a meter is called **multirange** voltmeter



The R:, R2, R) and R~ are the four series multipliers. When connected in series with the meter, they can give four different voltage ranges as V1, V2,V3, and V4. The selector switch S is multiposition switch by which the required multiplier can be selected in the circuit.

The mathematical analysis of basic d.c. *voltmeter* is equally applicable for such multirange *voltmeter*. Thus,

$$R_1 = \frac{V_1}{I_m} - R_m \qquad R_2 = \frac{V_2}{I_m} - R_m \qquad \text{and so on.}$$

Sensitivity of voltmeters:

In a multirange voltmeter, the ratio of the total resistance R r to the voltage range remains same. This ratio is nothing but the reciprocal of the full scale deflection current,of the meter i.e. 1/101. This value is called sensitivity of the voltmeter. Thus the sensitivity of the voltmeter is defined ,

$$S = \frac{1}{\text{Full scale deflection current}}$$

$$\boxed{S = \frac{1}{I_m}\ \Omega/V \text{ or } k\Omega/V}$$

True RMS Responding voltmeter

The voltmeters can be effectively used in a.c. voltmeters. The rectifier is used to convert a.c. voltage to be measured, to d.c. This d.c., if required is amplified and then given to the movement. The movement gives the deflection proportional to the quantity to be measured.

The r.m.s. value of an alternating quantity is given by that steady current (d.c.) which when flowing through a given circuit for a given time produces the same amount of heat as produced by the alternating current which when flowing through the same circuit for the same time. The r.m.s value is calculated by measuring the quantity at equal intervals for one complete cycle. Then squaring each quantity, the average of squared v,llues is obtained. The square root of this average value is the r.m.s. value. The r.m.s means root- mean square i.e. squaring, finding the mean i.e. average and finally root.

If the waveform is continuous then instead of squaring and calculating mean, the integratioll is used. Mathematically the r.m.s. value of the continuous a.c. voltage having time period T is given by,

$$V_{rms} = \sqrt{\frac{1}{T}\int_0^T V_{in}^2 \, dt}$$

The $\frac{1}{T}$ term indicates the mean value or average value.

For purely sinusoidal quantity,

$$V_{rms} = 0.707 \, V_m$$

where V_m = peak value of the sinusoidal quantity

If the a.c. quantity is continuous then average value can be expressed mathematically using an integration as,

$$V_{av} = \frac{2}{T}\int_0^{T/2} V_{in} \, dt$$

The interval T/2 indicates the average over half a cycle.

For **purely sinusoidal quantity,**

$$V_{av} = \frac{2}{\pi} V_m = 0.636 \quad V_m$$

where V_m = Peak value of the sinusoidal quantity.

The form factor is the ratio of r.m.s. value to the average value of an alternating quantity.

$$K_f = \frac{\text{r.m.s. value}}{\text{average value}} = \text{form factor}$$

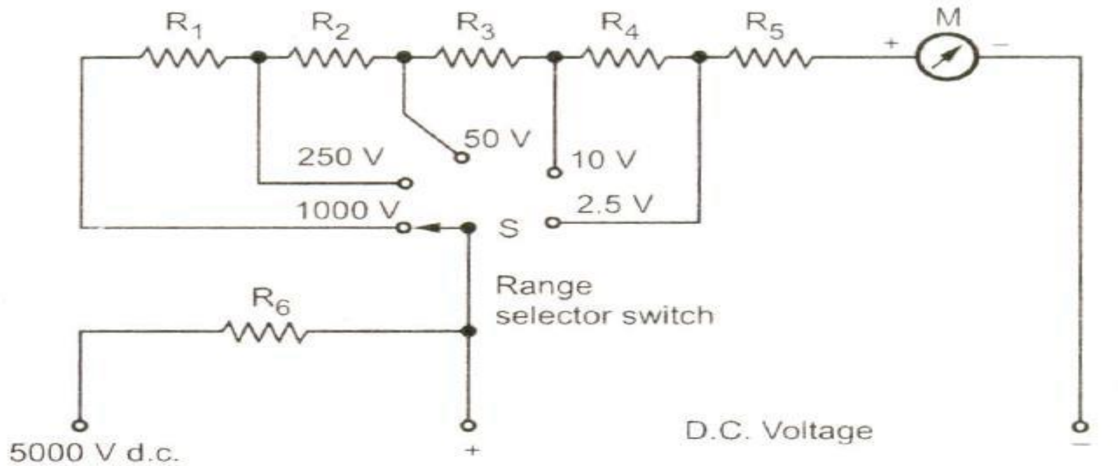
When the a.c. input is applied, for the positive half cycle, the diode 01 conducts and causes the meter deflection proportional to the average value of that half cycle. In the negative cycle, the diode O2 conducts and 01 is reverse biased. The current through the meter is in opposite direction and hence meter movement is bypassed. Thus due to diodes, the rectifying action produces pulsating d.c. and lile meter indicates the average value of the input.

Electronic multimeter:

For the measurement of d.c. as well as a.c. voltage and current, resistance, an electronic multimeter is commonly used. It is also known as Voltage-Ohm Meter (VOM) or multimeter The important salient features of YOM are as listed below.

1) The basic circuit of YOM includes balanced bridge d.c. amplifier.
2) To limit the magnitude of the input signal, RANGE switch is provided. By properly adjusting input attenuator input signal can be limited.
3) It also includes rectifier section which converts a.c. input signal to the d.c. voltage.
4) It facilitates resistance measurement with the help of internal battery and additional circuitry.
5) The various parameters measurement is possible by selecting required function using FUNCTION switch.
6) The measurement of various parameters is indicated with the help of indicating Meter.

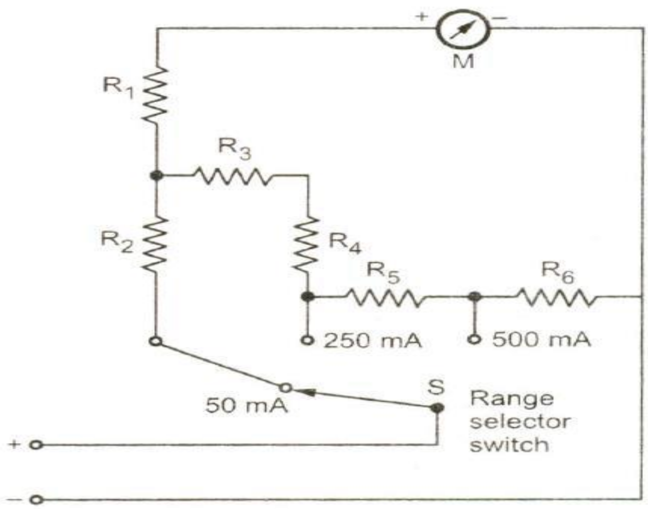
Use of multimeter for D.C measurement:



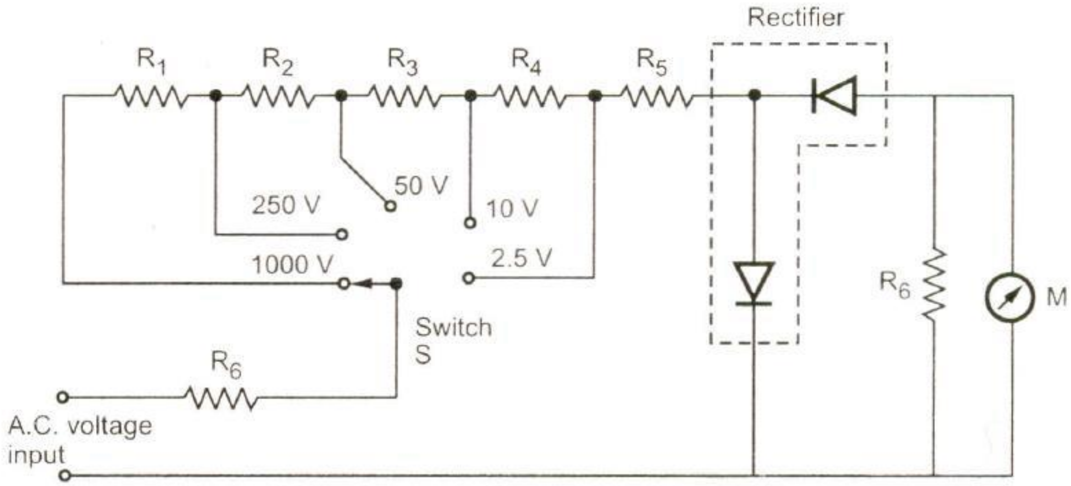
For getting different ranges of voltages, different series resistances are connected in series which can be put in the circuit with the range selector switch. We can get different ranges to measure the d.c. voltages by selecting the proper resistance in series with the basic meter.

Use of multimeter as ammeter:

To get different current ranges, different shunts are connected across the meter with the help of range selector switch. The working is same as that of PMMC



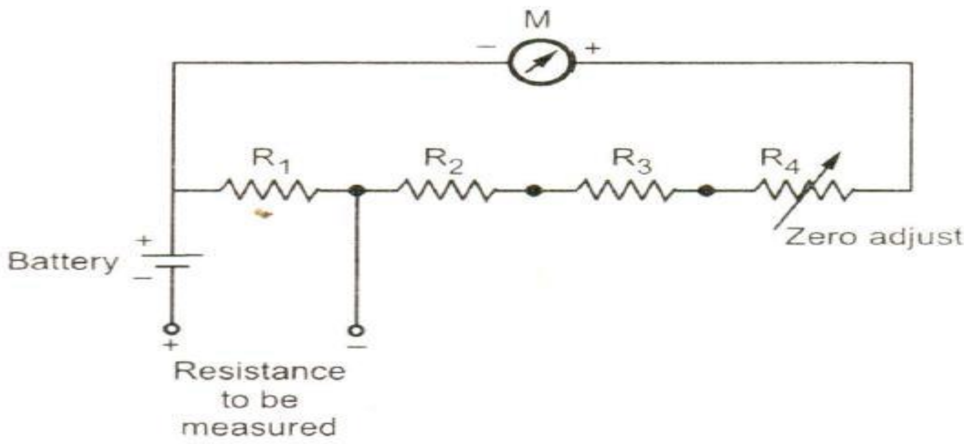
Use of multimeter for measurement of A.C voltage:



The rectifier used in the circuit rectifies a.c. voltage into d.c. voltage for measurement of a.c. voltage before current passes through the meter. The other diode is used for the protection purpose.

Use of multimeter for resistance measurement:

The Fig shows ohmmeter section of multimeter for a scale multiplication of 1. Before any measurement is made, the instrument is short circuited and "zero adjust" control is varied until the meter reads zero resistance i.e. it shows full scale current. Now the circuit takes the form of a variation of the shunt type ohmmeter. Scale multiplications of 100 and 10,000 can also be used for measuring high resistances. Voltages are applied the circuit with the help of battery.



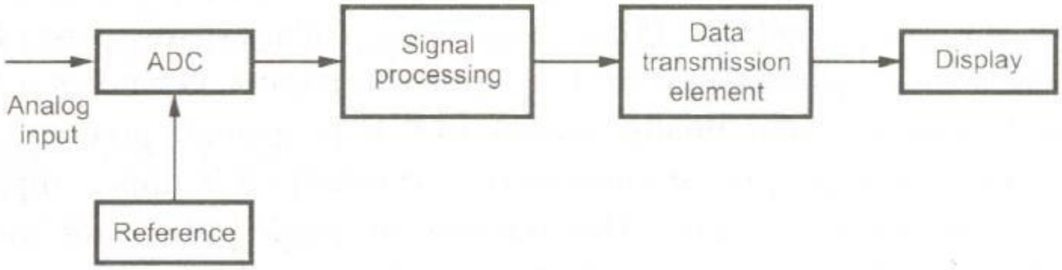
Digital Voltmeters

Performance parameters of digital voltmeters:

1. **Number of measurement ranges:**
The basic range of any DVM is either 1V or 10 V. With the help of attenuator at the Input, the range can be extended from few microvolts to kilovolts.
2. **Number of digits in readout:** The number of digits of DVMs varies from 3 to 6. More the number of digits, more is the resolution.
3. **Accuracy:** The accuracy depends on resolution and resolution on number of digits. Hence more number of digits means more accuracy. The accuracy is as high up to ± 0.005% of the reading.
4. **Speed of the reading:** In the digital voltmeters, it is necessary to convert analog signal into digital signal. The various techniques are used to achieve this conversion. The circuits which are used to achieve such conversion are called digitizing circuits and the process is called digitizing. The time required for this conversion is called digitizing period. The maximum speed of reading and the digitizing period are interrelated. The instrument user must wait, till a stable reading is obtained as it is impossible to follow the visual readout at high reading speeds.
5. **Normal mode noise rejection:** This is usually obtained through the input filtering or by use of the integration techniques. The noise present at the input, if passed to the analog to digital converting circuit then it can produce the error, especially when meter is used for low voltage measurement. Hence noise is required to be filtered.
6. **Common mode noise rejection :** This is usually obtained by guarding. A guard is a sheet metal box surrounding the circuitry. A terminal at the front panel makes this 'box' available to the circuit under measurement.
7. **Digital output of several types:** The digital readout of the instrument may be 4 lines BCD, single line serial output etc. Thus the type of digital output also determines the variety of the digital voltmeter.
8. **Input impedance :** The input impedance of DVM must be as high as possible which red l1ces the loading effects. Typically it is of the order of 10 :M.ohm.

Block diagram of DVM

Any digital instrument requires analog to digital converter at its input. Hence first block in a general DVM is ADC as shown in the Fig.



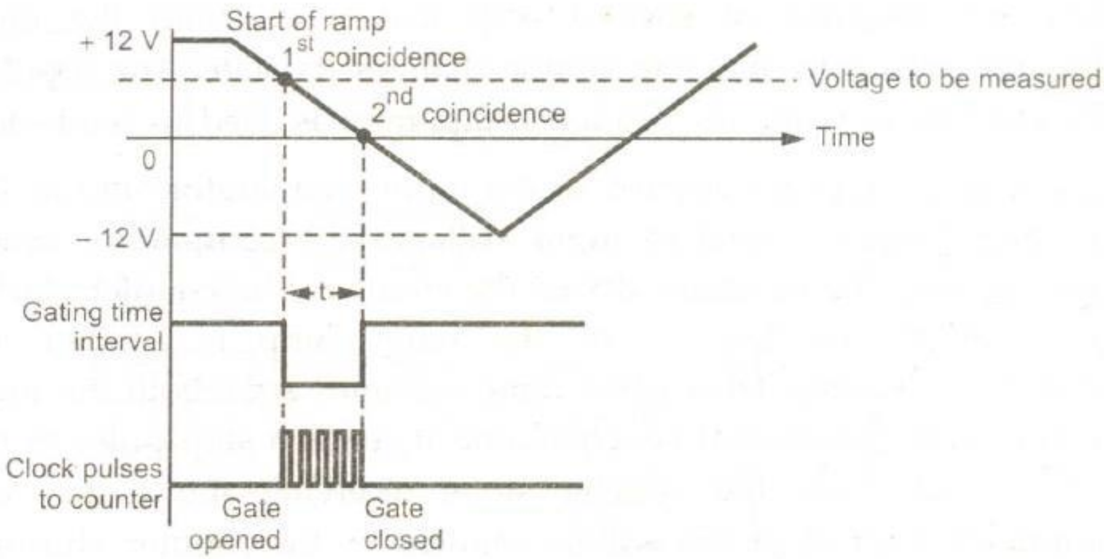
Every ADC requires a reference. The reference is generated internally and reference generator circuitry depends on the type of ADC technique used. The output of ADC is decoded and signal is processed in the decoding stage. Such a decoding is necessary to drive the seven segment display. The data from decoder is then transmitted to the display. The data transmission element may be a latches, counters etc. as per the requirement. A digital display shows the necessary digital result of the measurement.

Ramp type DVM:

Linear ramp technique:

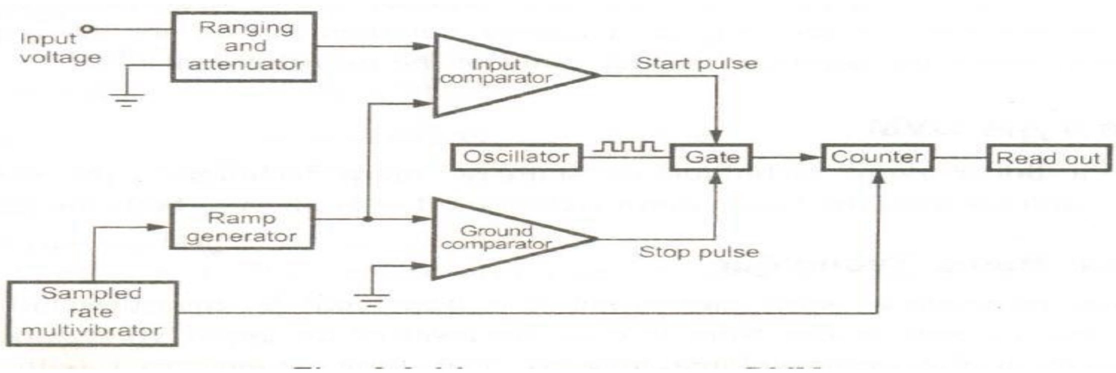
The basic principle of such measurement is based on the measurement of the time taken by l1 linear ramp to rise from a V to the level of the input voltage or to decrease from the level of the input voltage to zero. This time is measured with the help of electronic time interval counter and the count is displayed in the numeric form with the help of a digital

.



Basically it consists of a linear ramp which is positive going or negative going. The range of the ramp is ± 12 V while the base range is ± 10 V. The conversion from a *voltage* to c1 time interval is shown in the fig

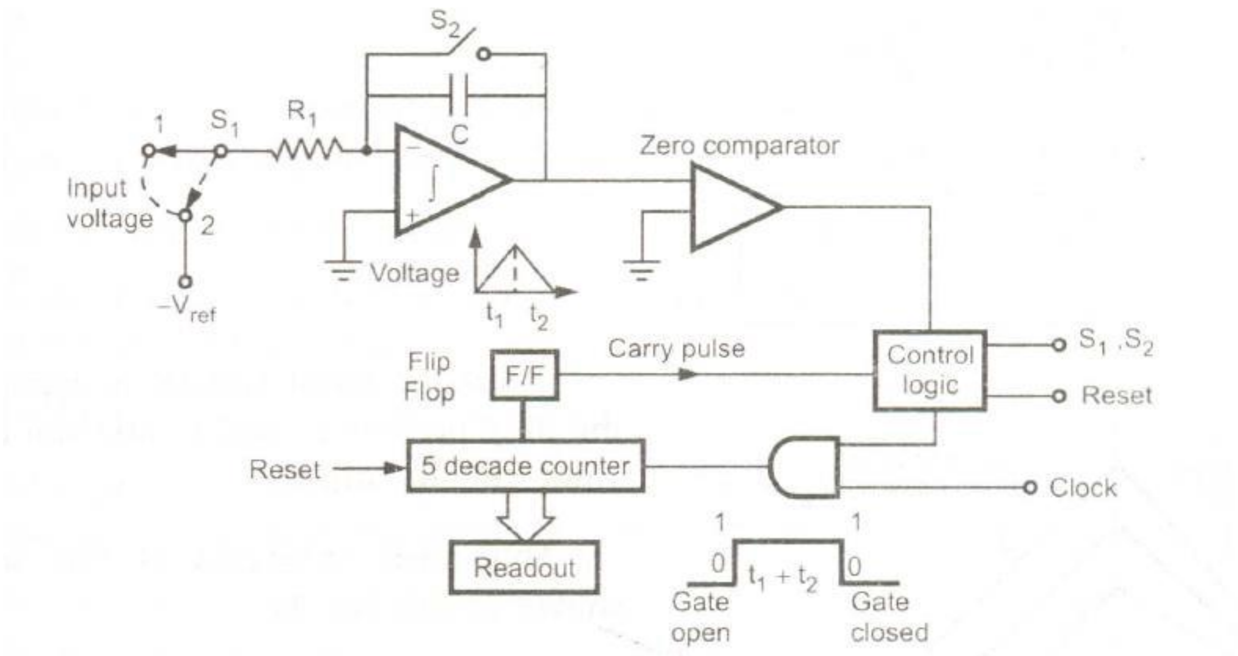
At the start of measurement, a ramp *voltage* is initiated which is continuously compared with the input voltage. When these two voltages are same, the comparator generates a pulse which opens a gate i.e. the input comparator generates a start pulse. The ramp continues to decrease and finally reaches to 0 V or ground potential. This is sensed by the second comparator or ground comparator. At exactly 0 V, this comparator produces a stop pulse which closes the gate. The number of clock pulses is measured by the counter. Thus the time duration for which the gate is opened, is proportional to the input voltage. FN the time interval between starts and stop pulses, the gate remains open and the oscillator circuit drives the counter. The magnitude of the count indicates the magnitude of the input voltage, which is displayed by the display. The block diagram of linear ramp DVM is shown in the Fig



Properly attenuated input signal is applied as one input to the input comparator. The ramp generator generates the proper linear ramp signal which is applied to both ten comparators. Initially the logic circuit sends a reset signal to the counter and the readout. The comparators are designed in such a way that when both the input signals of comparator are equal then only the comparator changes its state. The input comparator is used to send the start pulse while the ground comparator is used to send the stop pulse.
When the input and ramp are applied to the input comparator, and at the point when negative going ramp becomes equal to input voltages the comparator sends start pulse, due to which gate opens. The oscillator drives the counter. The counter starts counting the pulses *received* from the oscillator. Now the same ramp is applied to the ground comparator and it is decreasing. Thus when ramp becomes zero, both the inputs of ground compactor becomes zero (grounded) i.e. equal and it sends a stop pulse to the gate due to which gate gets closed. Thus the counter stops receiving the pulses from the local oscillator. A definite number of pulses will be counted by the counter, during the start and stop pulses which is measure of the input voltage. This is displayed by the digital readout.'
The sample rate multivibrator determines the rate at which the measurement cycles are initiated. The oscillation of this multivibrator is usually adjusted by a front panel control named rate, from few cycles per second to as high as 1000 or more cycles per second. The typical value is 5 measuring cycles/second with an accuracy of ± 0.005% of the reading. The sample rate provides an initiating pulse to the ramp generator to start its next ramp voltage. At the same time, a reset pulse is also generated which resets the counter to the zero state.

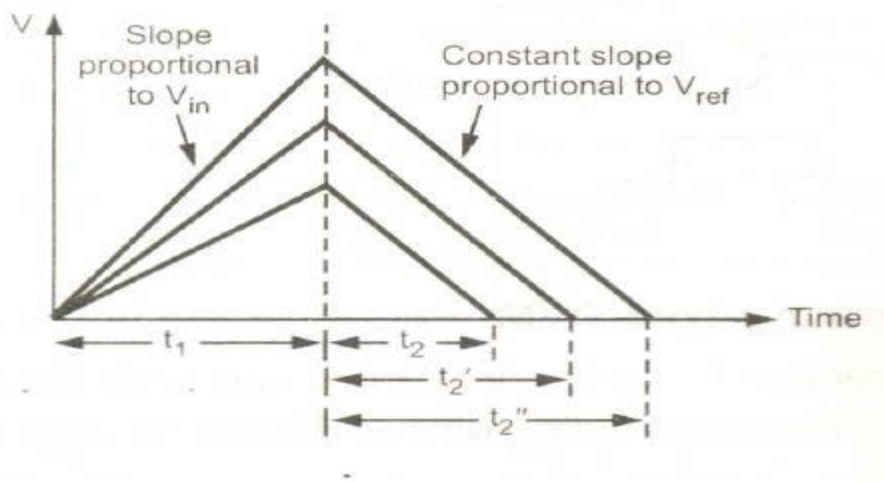
Dual slope integrating type DVM

This is the most popular method of analog to digital conversion. In the ramp techniques, the noise can cause large errors but in dual slope method the noise is averaged out by the positive and negative ramps using the process of integration. The basic principle of this method is that the input signal is integrated for a fixed interval of time. And then the same integrator is used to integrate the reference voltage with reverse slope. Hence the name given to the technique is **dual** slope integration technique.
The block diagram of dual slope integrating type DVM is shown in the Fig. It consists of five blocks, an op-amp used as an integrator, a zero comparator, clock pulse generator, a set of decimal counters and a block of control logic.



When the switch Sl is in position 1, the capacitor C starts charging from zero level. The rate of charging is proportional to the input voltage level. The output of the op-amp is given by,

After the interval t I, the input voltage is disconnected and a negative voltage -Vref is connected by throwing the switch S1 in position 2. In this position, the output of the op-ilmp is given by,



Thus the input voltage is dependent on the time periods t] and t2 and not on the values of R] and C. This basic principle of this method is shown in the Fig.

At the start of the measurement, the counter is resetted to zero. The output of the flip-flop is also zero. This is given to the control logic. This control sends a signal so as to close an electronic switch to position 1 and integration of the input voltage starts. It continues till the time period t.

As the output of the integrator changes from its zero value, the zero comparator output changes its state. This provides a signal to control logic which inturn opens the gate and the counting of the clock pulses starts.

The counter counts the pulses and when it reaches to 9999, it generates a carry pulse and all digits go to zero. The flip flop output gets activated to the logic level T. This activates the control logic. This sends a signal which changes the switch 5\ position from 1 to 2 Thus -Vref gets connected to op-amp. As Vref polarity is opposite, the capacitor starts discharging. The integrator output will have constant negative slope as shown in the Fig. 3.5"1. The output decreases linearly and after the interval t2, attains zero value, when the capacitor C gets fully discharged.

From equation (3) we can write,

$$V_{in} = V_{ref} \cdot \frac{t_2}{t_1}$$

Let time period of clock oscillator be T and digital counter has counted the counts n1 and n2 during the period t] and t2 respectively.

$$V_{in} = V_{ref} \cdot \frac{n_2 T}{n_1 T} = V_{ref} \cdot \frac{n_2}{n_1}$$

Thus the unknown voltage measurement is not dependent on the clock frequency, but dependent on the counts measured by the counter.

The advantages of this technique are:

i) Excellent noise rejection as noise and superimposed arc. are averaged out during the process of integration.

ii) The RC time constant does not affect the input voltage measurement.

iii)The capacitor is connected via an electronic switch. This capacitor is an auto zero capacitor and avoids the effects of offset voltage.

iv)The integrator responds to the average value of the input hence sample and hold circuit is not necessary.

v) The accuracy is high and can be readily varied according to the specific requirements.

Questions:

1. Explain the construction and working of i) Phase sequence indicators
   ii) Electrodynamometer type power factor meters

July/Aug -2007, Jan/ Feb -2011, July/Aug -2009, Jan/ Feb -2012

2) With a neat sketch explain the construction and working of a Weston frequency meter
July/Aug -2004, Jan/ Feb -2005

3) What is a rotating type phase sequence indicator and how it is used
July/Aug -2008, Jan/ Feb -2009, Jan/ Feb 2012

4. Explain the principle of operation of a static type of phase sequence indicator
July/Aug -2006, Jan/ Feb -2011
5. Discuss about the working principle of digital voltmeter employing the successive approximation technique
July/Aug-2005, Jan/Feb-2005, July/Aug-2009, Jan/ Feb -2004, Jan/ Feb -2010
6. Discuss the different practical method of connection the unknown components to the test terminals of a Q meter Jan/ Feb -2004

1. With a block diagram explain the working of a True RMS responding voltmeter
July/Aug-2004, Jan/Feb-2007, July/Aug-2009, Jan/ Feb -2005, Jan/ Feb -2008
July/Aug-2008, Jan/Feb-2009, July/Aug-2010, Jan/ Feb -2011
2. With a block diagram explain the working of a Ramp type DVM
July/Aug-2004, July/Aug-2010
3. List the elements of the basic circuit of an electronic multimeter
July/Aug-2004
4. What is a Q meter? Discuss how the unknown components can be connected to its test terminals July/Aug-2005
5. Explain with the help of block diagram the function of integrating type digital voltmeter Jan/ Feb -2006
6. Explain the principle of operation of electronic multimeter
July/Aug-2007, Jan/Feb-2006
7. Explain with block diagram any one type of digital voltmeter
July/Aug-2006
8. What are the advantages of using electronic measuring instruments
July/Aug-2007
9. Explain the operation of a electronic multimeter to measure current, voltage and resistance Jan/ Feb -2011
10. What is the working principle of Q-Meter? How can the distributed capacitance of the coil be measured using Q-Meter? July/Aug-2006 , Jan/ Feb 2012
11. Mention the salient features of digital voltmeter
July/Aug-2007

Module-5

Display devices and Recording deices

Introduction

In studying the various electronic, electrical networks and systems, signals which are functions of time, are often encountered. Such signals may be periodic or non periodic in nature. The device which allows, the amplitude of such signals, to be displayed primarily as " function of time, is called **cathode ray** oscilloscope, commonly known as C.R.O. The CR.O gives the visual representation of the time varying signals. The oscilloscope has become an universal instrument and is probably most versatile tool for the development of electronic circuits and systems. It is an integral part of electronic laboratories.

The oscilloscope is, in fact, a voltmeter. Instead of the mechanical deflection of a metallic pointer as used in the normal voltmeters, the oscilloscope uses the movement of an electron beam against a fluorescent screen, which produces the movement of a visible spot. The movement of such spot on the screen is proportional to the varying magnitude of the signal, which is under measurement.

Basic Principle

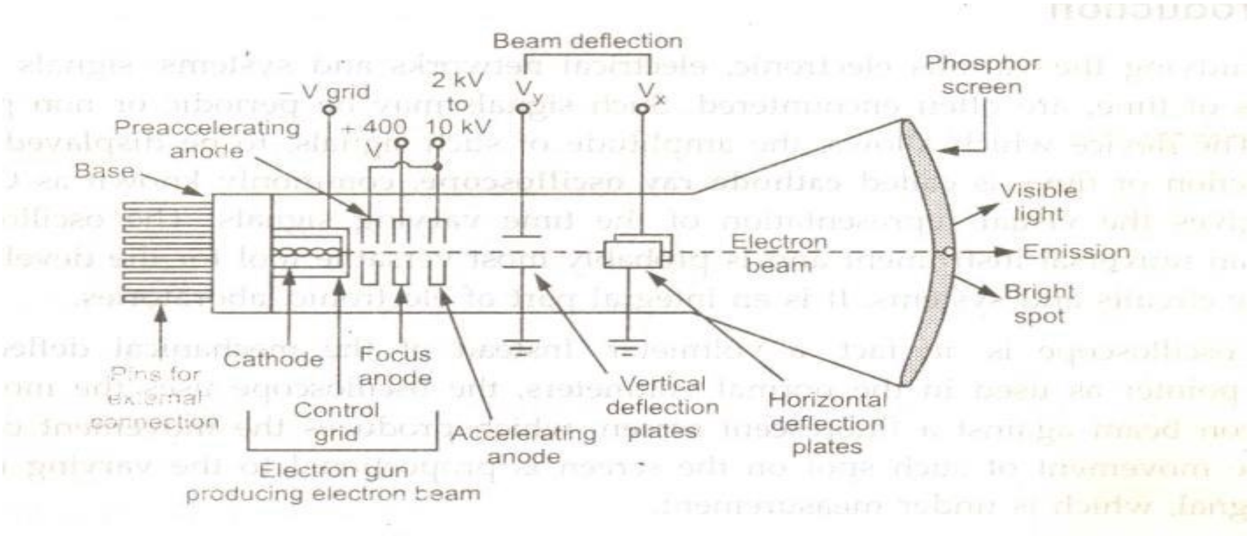
The electron beam can be deflected in two directions : the horizontal or x-direction and the vertical or y-direction. Thus an electron beam producing a spot can be used to produce two dimensional displays, Thus CRO. can be regarded as a fast x-y plotter. The x-axis and y-axis can be used to study the variation of one voltage as a function of another. Typically the x-axis of the oscilloscope represents the time while the y-axis represents variation of the input voltage signal. Thus if the input voltage signal applied to the y-axis of CRO. is sinusoidally varying and if x-axis represents the time axis, then the spot moves sinusoidally, and the familiar sinusoidal waveform can be seen on the screen of the oscilloscope. The oscilloscope is so fast device that it can display the periodic signals whose time period is as small as microseconds and even nanoseconds. The CRO. Basically operates on voltages, but it is possible to convert current, pressure, strain, acceleration and other physical quantities into the voltage using transducers and obtain their visual representations on the CRO.

Cathode Ray Tube (CRT)

The cathode ray tube (CRT) is the heart of the CR.O. the CRT generates the electron beam, ,accelerates the beam, deflects the beam and also has a screen where beam becomes visible ,as a spot. The main parts of the CRT are:

i) Electron gun ii) Deflection system iii) Fluorescent screen
iv) Glass tube or envelope v) Base

A schematic diagram of CRT, showing its structure and main components is shown in the Fig.



Electron Gun

The electron gun section of the cathode ray tube provides a sharply focused electron beam directed :towards the fluorescent-coated screen. This section starts from theql1ally heated cathode, limiting the electrons. The control grid is give!! negative potential with respect to cathode dc. This grid controls the number of electrons in the beam, going to the screen.

The momentum of the electrons (their number x their speed) determines the intensity, or brightness, of the light emitted from the fluorescent screen due to the electron bombclrdl1lent. The light emitted is usually of the green colour. Because the electrons are negatively charged, arepulsive force is created by applying a negative voltage to the control grid (in CRT, voltages applied to various grids are stated with respect to cathode, which is taken as common point). This negative control voltage can be made varia

Deflection System

When the electron beam is accelerated it passes through the deflection system, with which beam can be positioned anywhere on the screen. The deflection system of the cathode-ray-tube consists of two pairs of parallel plates, referred to as the vertical and horizontal deflection plates. One of the plates' in each set is connected to ground (0 V), To the other plate of each set, the external deflection voltage is applied through an internal adjustable gain amplifier stage, To apply the deflection voltage externally, an external terminal, called the Y input or the X input, is available.

As shown in the Fig. , the electron beam passes through these plates. A positive voltage applied to the Y input terminal (Vy) Causes the beam to deflect vertically upward due to the attraction forces, while a negative voltage applied to. the Y input terminal will cause the electron beam to deflect vertically downward, due to the repulsion forces.

When the voltages are applied simultaneously to vertical and horizontcl1 deflecting plates, the electron beam is deflected due to the resultant-of these two voltages.

Fluorescent Screen

The light produced by the screen does not disappear immediately when bombardment by electrons ceases, i.e., when the signal becomes zero. The time period for which the trace remains on the screen after the signal becomes zero is known as "persistence". The persistence may be *jS* short as a few microsecond, or as long as tens of seconds ~en minutes.

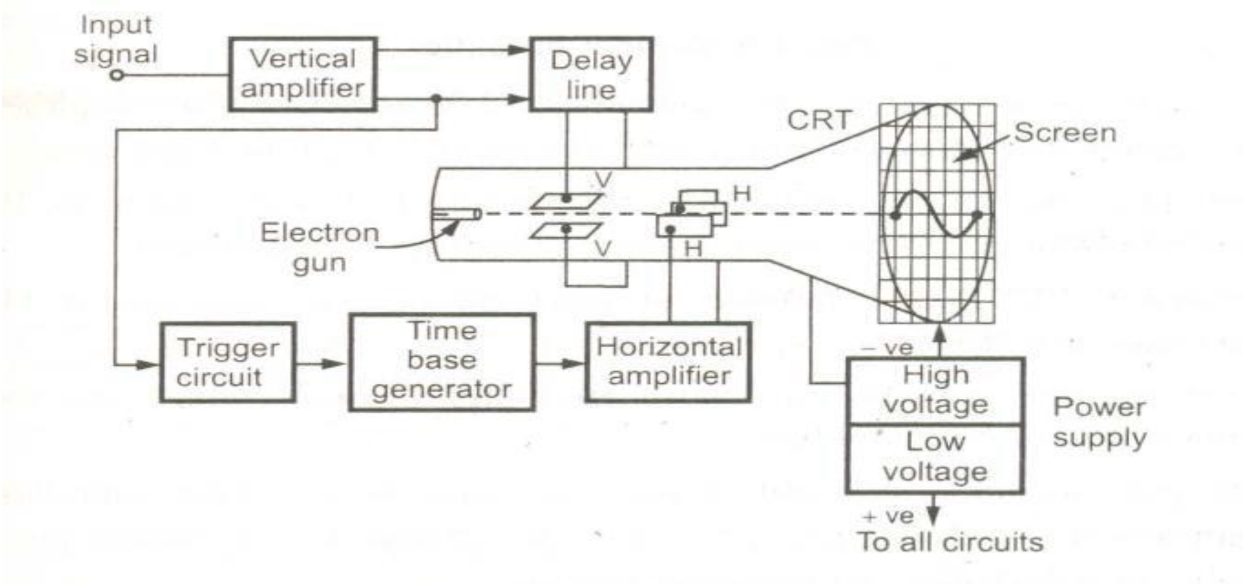
Long persistence traces are used in the study.. of transients. Long persistence helps in the study of transients since the trace is still seen on the screen after the transient has disappeared.

Phosphor screen characteristics

Many phosphor materials having different excitation times and colours as well as different phosphorescence times are available. The type PI, P2, PI1 or P3I are the short persistence phosphors and are used for the general purpose oscilloscope

Medical oscilloscopes require a longer phosphor decay and hence phosphors like P7 and P39 are preferred for such applications. Very slow displays like radar require long persistence phosphors to maintain sufficient flicker free picture. Such phosphors are P19, P26 and, P33.

The phosphors P19, P26, P33 have low burn resistance. The phosphors PI, P2, P4, P7, Pll have medium burn resistance while PIS, P3I have high burn resistance.

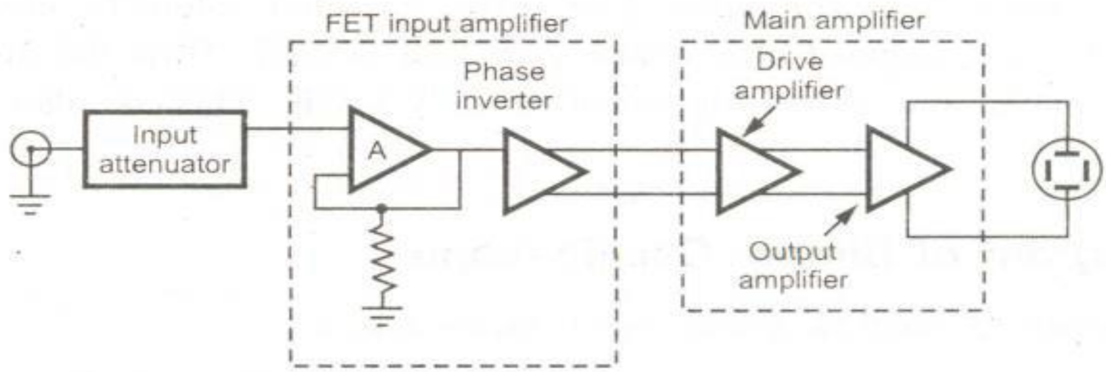


CRT

This is the cathode ray tube which is the heart of CR.O. It is' used to emit the rlectrons required to strike the phosphor screen to produce the spot for the visual display of the signals.

Vertical Amplifier

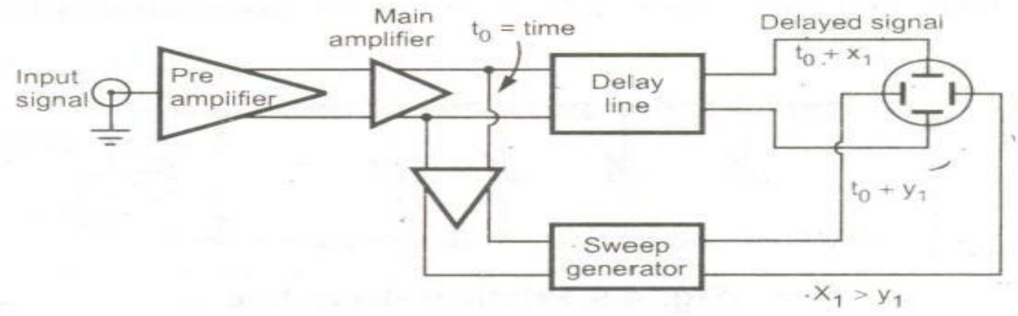
The input signals are generally not strong to provide the measurable deflection on the screen. Hence the vertical amplifier. stage is used Jo amplify the input signals. The amplifier stages used are generally wide band amplifiers so as to pass faithfully the entire band of frequencies to be measured. Similarly it contains the attenuator stages as well. The attenuators are used when very high voltage signals are to be examined, to bring the signals within the proper range of operation.



It consists of several stages with overall fixed sensltivity. The amplifier can be designed for stability and required bandwidth very easily due to the fixed gain. The input stage consists of an attenuator followed by FET source follower. It has vel' high input impedance required to isolate the amplifier from the attenuator. It is followed by BJT emitter follower to match the output impedance of FET output With input of phase inverter. The phase inverter provides two antiphase output signals which are required to operate the push pull output amplifier. The push pull operation has advantages like better hum voltage cancellation, even harmonic suppression especially large 2nd harmonic, greater power output per tube and reduced number of defocusing and nonlinear effects.

Delay line

The delay line is used to delay the signal for some time in the verticClI sections. When the delay line is not used, the part of the signal gets lost. Thus the input signal is not applied directly to the vertical plates but is delClyed bv some time using a delay line cu-cuit as shown in the Fig.



If the trigger pulse is picked off at a time t = to after the signal has passed through the main amplifier then signal is delayed by XI nanoseconds while sweep takes YI nanoseconds to reach. The design of delay line is such that the delay time XI is higher than the time YI' Generally XI is 200. nsec while tl;1.eYI is 80 ns, thus the sweep starts well in time and no part of the signal is lost.

There are two types of delay lines used in CR.O. which are:

i) Lumped parameter delay line

ii) Distributed parameter delay line

Trigger circuit

It is necessary that horizontal deflection starts at the same point of the input vertical signal, each time it sweeps. Hence to synchronize horizontal deflection with vertical deflection a synchronizing or triggering circuit is used. It converts the incoming signal into the triggering pulses, which are used for the synchronization.

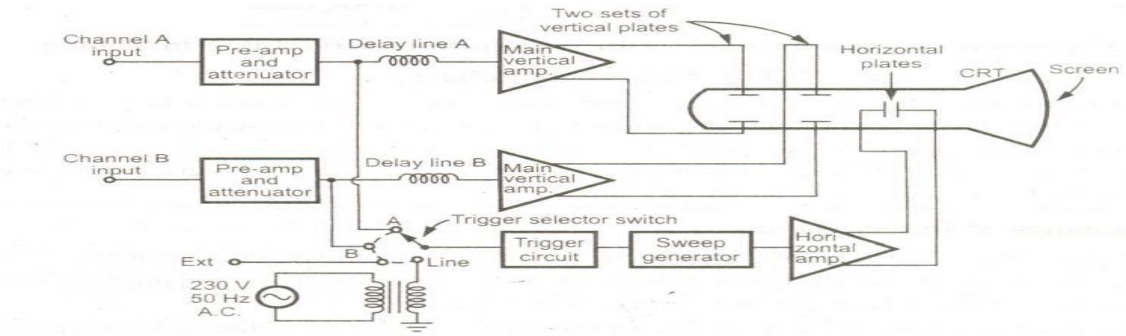
Time base generator

The time base generator is used to generate the sawtooth voltage, required to deflect the beam in the horizontal section. This voltage deflects the spot at a constant time dependent rate. Thus the x-axis' on the screen can be represented as time, which, helps to display and analyse the time varying signals.

Dual trace Oscilloscope

Another method of studying two voltages simultaneously on the screen is to u special cathode ray tube having two separate electron guns generating two separate beami Each electron beam has its own vertical deflection plates.

But the two beams are deflected horizontally by the common set of horizontal plate\ The time base circuit may be same or different. Such an oscilloscope is called **Dual** Beam Oscilloscope.

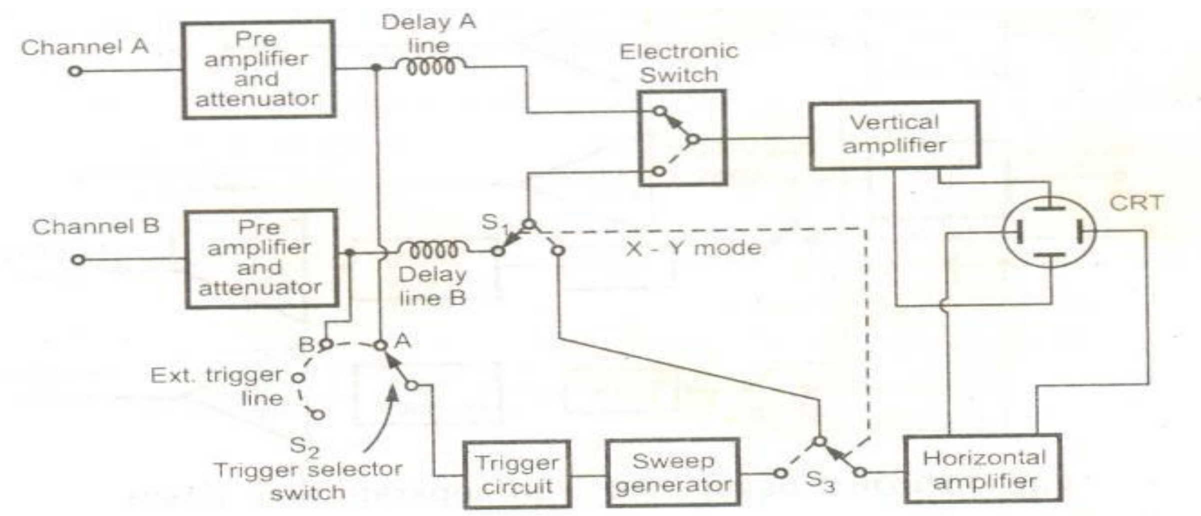


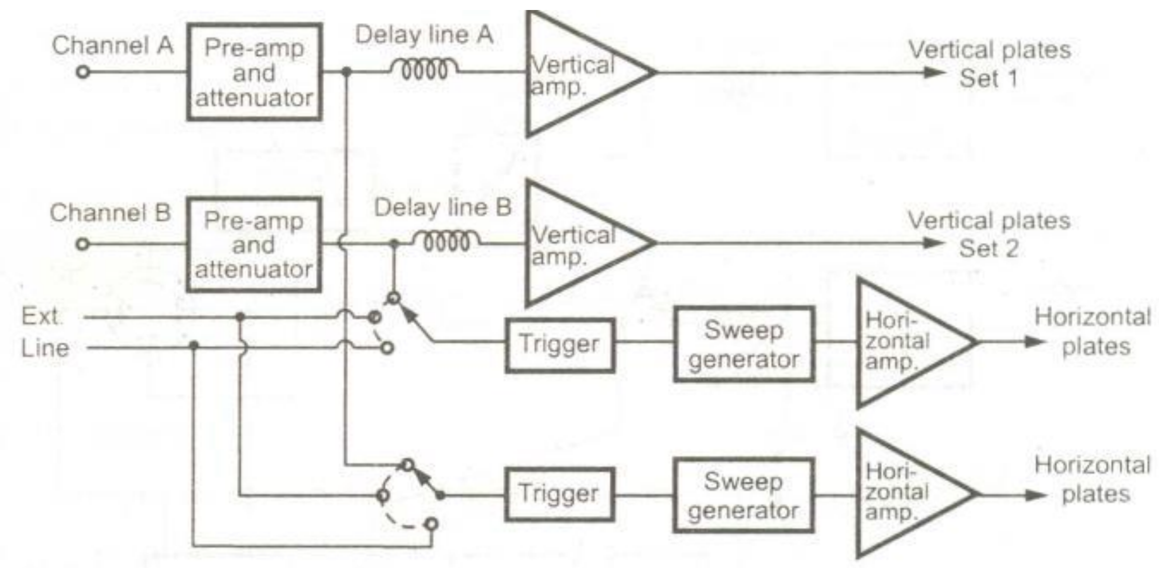
The oscilloscope has two vertical deflection plates and two separate channels A and B for the two separate input signals. Each channel consists of a preamplifier and an attenuator. A delay line, main vertical amplifier and a set of vertical deflection plates together forms a single channel. There is a single set of horizontal plates and single time base circuit. The sweep generator drives the horizontal amplifier which inturn drives the plates. The' horizontal plates sweep both the beams across the screen at the same rate. The sweep generator can be triggered internally by the channel A signal or .channel B signal. Similarly it' can also be triggered from an external signal or line frequency signal. This is possible with the help of trigger selector switch, a front panel control. Such an oscilloscope may have separate timebase circuit for separate channel. This allows different sweep rates for the two channels but increases the size and weight of the oscilloscope.

The comparison of two or more voltages is very much ,necessary in the analysis and study of many electronic circuits and systems. This is possible by using more than one oscilloscope but in such a case it is difficult to trigger the sweep of each oscilloscope precisely at the same time. A common and less costly method to solve this problem is to use dual trace or multitrace oscilloscopes. In this method, the same electron beam is used to generate two traces which can be deflected from two independent vertical sources. The methods are used to generate two independent traces which the alternate sweep method and other is chop method.

The block diagram of dual trace oscilloscope is shown in the Fig

There are two separate vertical input channels A and B. A separate preamplifier and -attenuator stage exists for each channel. Hence amplitude of each input can be individually controlled. After preamplifier stage, both the signals are fed to an electronic switch. The switch has an ability to pass one channel at a time via delay line to the vertical amplifier. The time base circuit uses a trigger selector switch 52 which allows the circuit to be triggered on either A or B channel, on line frequency or on an external signal. The horizontal amplifier is fed from the sweep generator or the B channel via switch 5! and 51. The X-Y mode means, the oscilloscope operates from channel A as the vertical signal and the channel B as the horizontal signal. Thus in this mode very accurate X-Y measurements can be done.





Dual beam CRO with separate time bases

Method of Measuring

Measuring oscilloscope has a single tube but several beam producing systems inside. Each system has separate vertical deflecting pair of plates and generally (l common time base system.

The triggering can be done internally using eith.er of the multiple inputs or externally by an external signal or line voltages.

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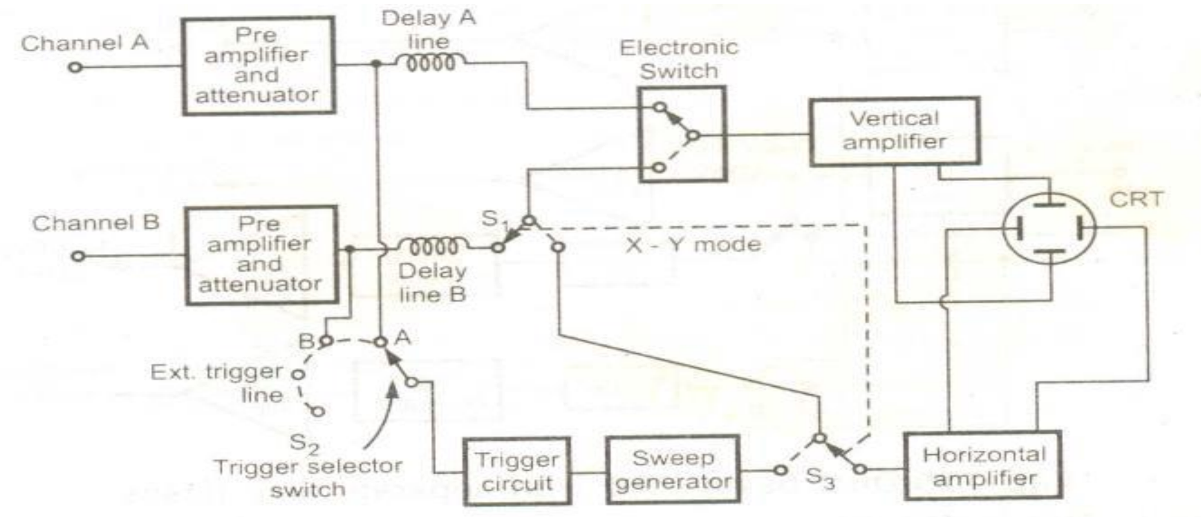
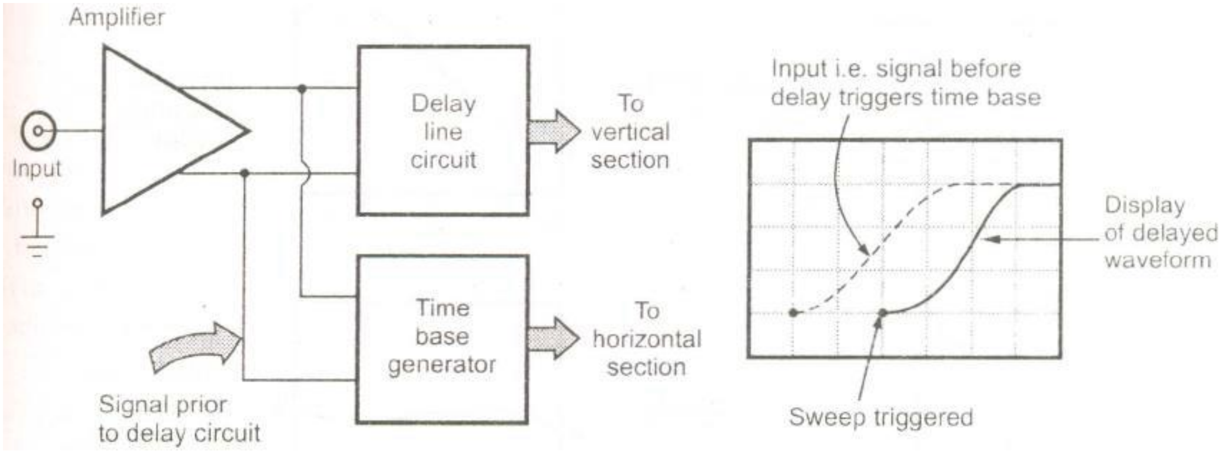
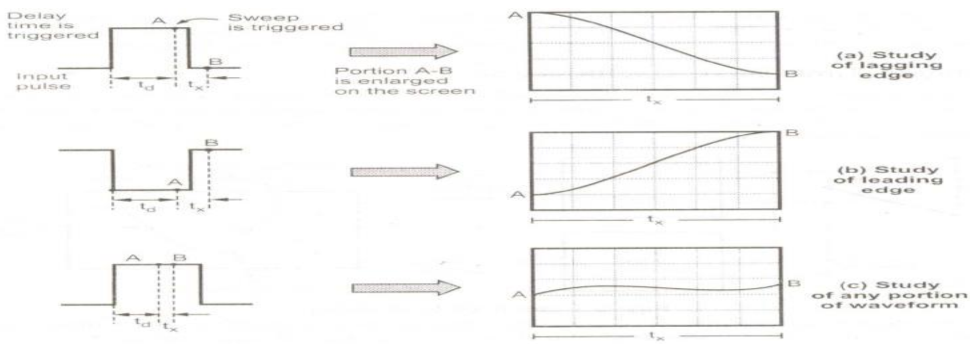




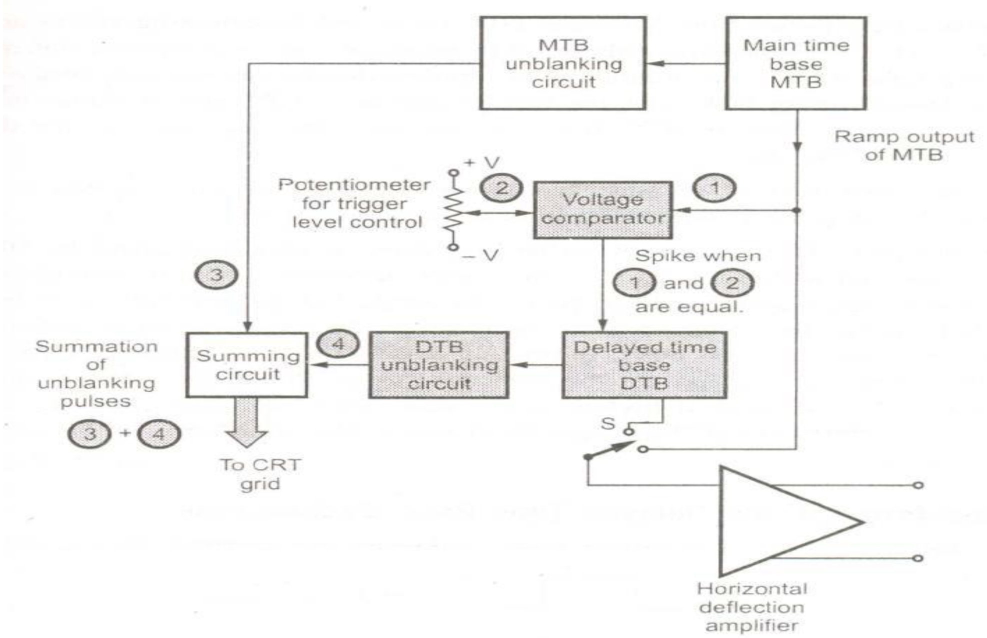
Due to triggering of time base by input signal, sweep starts well in time and when input appears at vertical sections, the sweep is triggered and delayed W(l\ dorm is displayed. The delay ensures that no part of the waveform gets lost.

In c1 delayed time base oscilloscope, a variable time delay circuit is used in the basic time base circuit. This allows the triggering of sweep time after the delay time. Thus the delay time is variable. This time is denoted as td. After this, the sweep is triggered for the time t,. Then the portion of the waveform for the time t x gets expanded on the complete () oscilloscope screen, for the detail study.

If inpu, t is pulse waveform and leading edge is used to trigger the delay time, then lagging edge can be displayed to fill the entire oscilloscope screen. This is shown in the Fig (a). Similarly if the lagging edge is used to trigger the delay time then leading edge Glen be displayed on the entire screen for the time t. This is shown in the Fig.(b). If the time delay is perfectly adjusted, then any portion of the waveform can be extended to fill the entire screen. This is shown in the Fig. (c).



Use of additional time delay

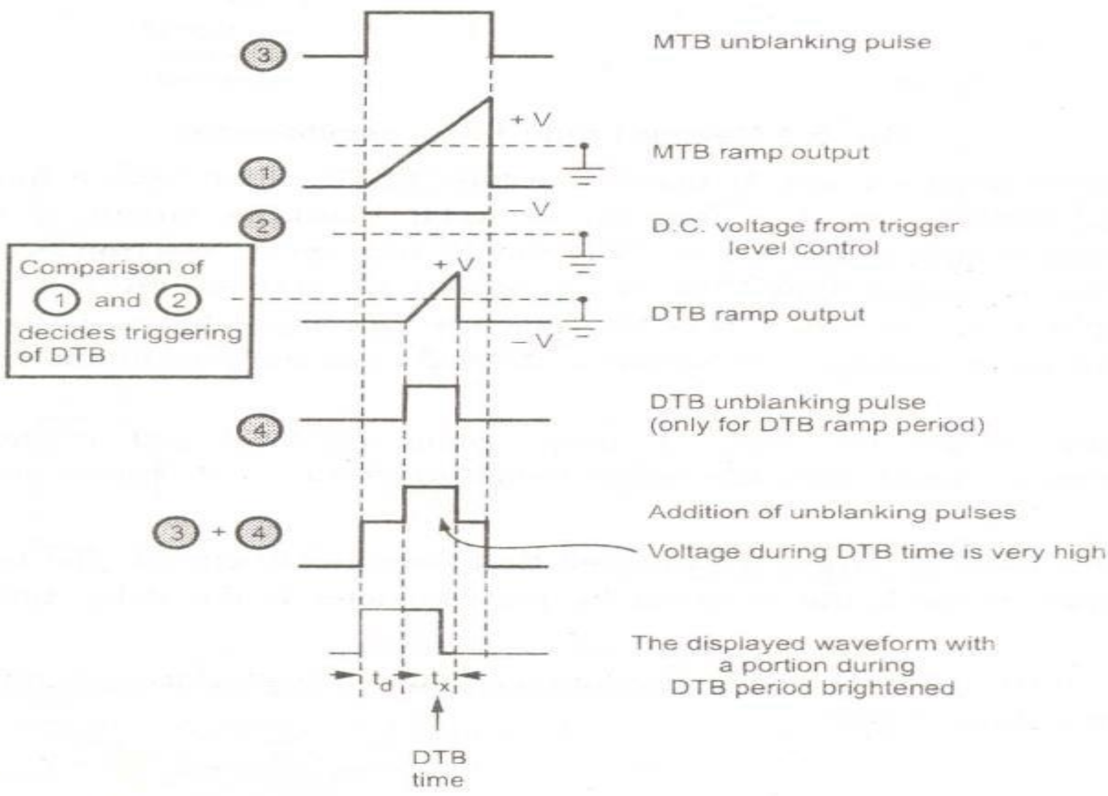


Delayed time base oscilloscope

The normal time base circuit is main time base (MTB) circuit which functions same as c1 conventional oscilloscope. The function of MTB blanking circuit is to produce an unblanking pulse which is applied to CRT grid to turn on an electron beam in the CRT, during the display sweep time. The ramp output of MTB is given to the horizontal deflection amplifier via switch S. It is also given as one input to the voltage comparator. The other input to the voltage comparator is derived from the potentiometer whose level is adjustable.

The unbalancing pulses from MTB and DTB are added by **summing circuit** and given to the CRT grid. The un blanking pulse of MTB produces a trace of uniform intensity. But during ramp time of DTB, the addition of two pulses decides the intensity of the trace on the screen. Hence during DTB time, the voltage applied to CRT grid is almost twice than the voltage corresponding to MTB time. This increases the brightness of the displayed waveform for the DTB time.

When the part of the waveform to be brightened is identified, then the DTB ramp output is connected to the input of the horizontal deflection amplifier through switch S. The DTB ramp time is much smaller than MTB period but its amplitude (- V to + V) is same as MTB ramp. 1Ience it causes the oscilloscope electron beam to be deflected from one side of the screen to the other, during short DTB time. By adjusting DTB time/ div control, the brightened portion can be extended, so as to fill the entire screen of the oscilloscope. The horizontal deflection starts only after the delay time t d from the beginning of the MTB sweep. Thus very small part of the waveform can be extended on the entire screen.

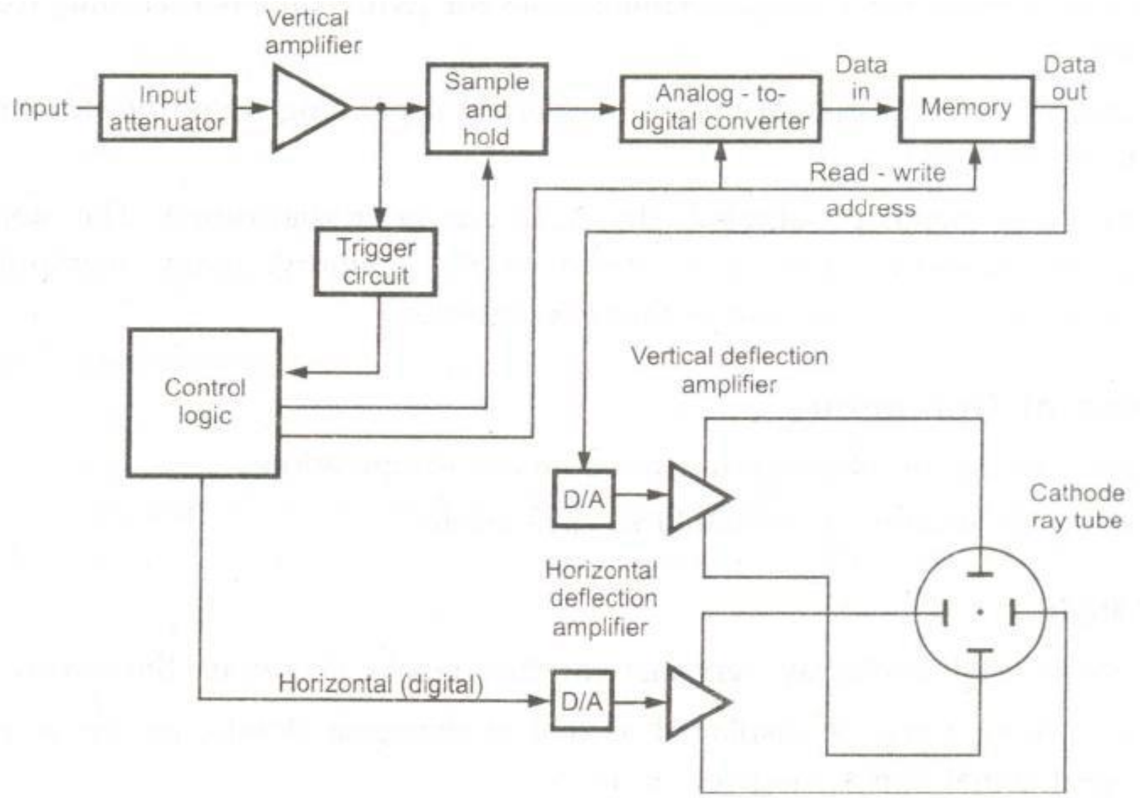


Digital Storage Oscilloscope

In this digital storage oscilloscope, the waveform to be stored is digitized ,md then stored in a digital memory. The conventional cathode ray tube is used in this oscilloscope hence the cost is less. The power to be applied to memory is small and can be supplied by small battery. Due to this the stored image can be displayed indefinitely as long ,15 power is supplied to memory. Once the waveform is digitized then it can be further loaded into the computer and can be analyzed in detail.

Block Diagram:

The block diagram of digital storage oscilloscope is shown in the Fig.



As done in all the oscilloscopes, the input signal is applied to the amplifier and attenuator section. The oscilloscope uses same type of amplifier and attenuator circuitry as used in the conventional oscilloscopes. The attenuated signal is then applied to the vertical amplifier.

The vertical input, after passing through the vertical amplifier, is digitized by an analog to digital converter to create a data set that is stored in the memory. The data set is processed by the microprocessor and then sent to the display.

To digitize the analog signal, analog to digital *(AID)* converter is used. The output of the vertical amplifier is applied to the *AID* converter section. The main requirement of *AID* converter in the digital storage oscilloscope is its speed, while in digital voltmeters accuracy and resolution were the main requirements. The digitized output needed only in the binary form and not in BCD. The successive approximation type of *AID* converter is most often used in the digital storage oscilloscopes.

Modes of operation:

The digital storage oscilloscope has three modes of operation:

1. Roll mode ii) Store mode iii) Hold or save mode.

Roll mode

This mode is used to display very fast varying signals, clearly on the screen. The fast varying signal is displayed as if it is changing slowly, on the screen. In this mode, the input signal is not triggered at all.

It is a primary electrical which is used to measure the change in the t. It is commonly known as resistance thermometer. The resistance thermometers are based on the principle that the resistance of the conductor changes when ~he temperature changes. Basically the resistance thermometer determines the' change in the electrical resistance of the conductor subjected to the temperature changes. The temperature sensing element used in this thermometer should exhibit a relatively large change in resistance for a given change in temperature. Also the sensing element should not undergo permanent change with use or age. Another desirable characteristic for the sensing element is the linear change in resistance with change in temperature. When the sensing element is smaller in size, less heat is required to raise its temperature. This is suitable for measurement of rapid variations in temperature. Platinum, nickel, and copper are the metals most commonly used to measure temperature. The relationship between temperature and resistance of conductor is given by equation:

Almost all metallic conductors have a *positive temperature coefficient* so that their resistance increases with an increase in temperature. A high value of a is desirable in a temperature sensing element so that a substantial change in resistance occurs for a relatively small change in temperature. This change in resistance *[L* R] can be measured with a Wheatstone bridge, the output of which can be directly calibrated to indicate the temperature which caused the change is resistance.

Most of the metals show an increase in resistivity with temperature, which is first linear and then increases in an accelerated fashion. The metals that exhibit good sensitivity and reproducibility for temperature measurement purposes are copper, nickel, and platinum. Among these, copper has the highest temperature coefficient with the most linear dependence. However, copper is generally not used due to certain practical problems. Because of its low resistively, the size of the resistance element increases to get reasonable sensitivity. In the range below 400 K, a gold silver alloy can be used which has the same characteristics as platinum.

The wire resistance thermometer usually consists of a coil wound on a mica or ceramic former, as shown in the Fig. The coil is wound in bifilar form so as to make it non inductive. Such coils are available in different sizes and with different resistance values ranging from 10 ohms to 25,000 ohms. To avoid corrosion of resistive element, usually elements are enclosed in a protective tube of Pyrex glass, porcelain, quartz or nickel, depending on the range of temperature and the nature of the fluid whose temperature is to be measured. The tube is evacuated and sealed or filled with air or any other inert gas and kept around atmospheric pressure or in some cases.

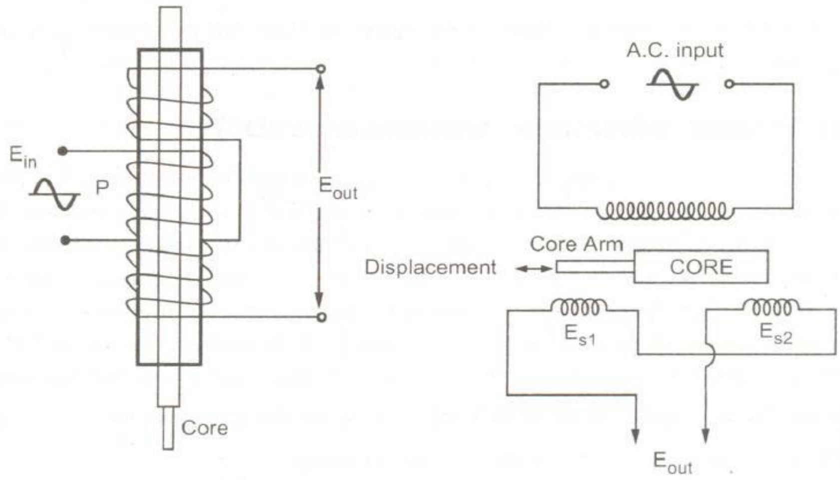
Questions

1. With a neat block diagram explain the working of a digital storage oscilloscope
   Jan/ Feb -2008, Jan/ Feb 2012
2. Explain the significance of lissajous pattern
   Jan/ Feb -2008, July/Aug-2008,2009

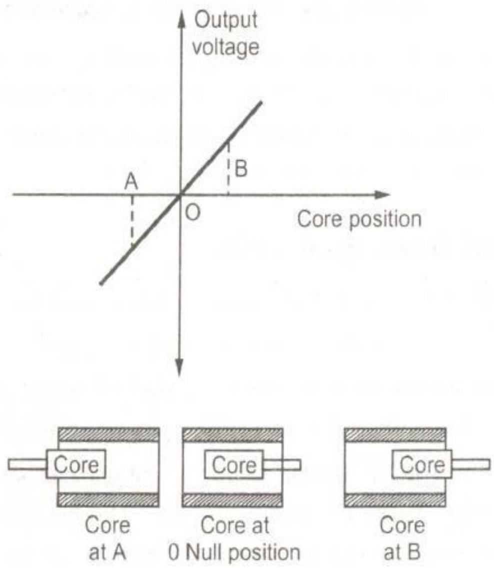
4) Explain the panel details of a dual trace oscilloscope
   July/Aug-2008, 2010
5) Write a note on CRO and its applications
   Jan/ Feb -2009

6) Explain with the help of block diagram of dual trace oscilloscope
Jan/ Feb -2010, July/Aug-2009
7) Explain the working of digital storage oscilloscope
Jan/ Feb -2010,2011, July/Aug-2010, Jan/ Feb 2012

Linear variable differential transformer (LVDT)



When an externally applied force moves the core to the left-hand position, more magnetic flux links the left-hand coil than the right-hand coil. The emf induced in the left-hand coil, ES], is therefore larger than the induced emf of the right-hand [oil, Es2' The magnitude of the output voltage is then equal to the difference between the two secondary voltages and it is in phase with the voltage of the left-hand coil.



Previous Question Paper Questions

1. Explain LVDT? May/June08
2. What are the various classification of gauges?Dec/Jan2010
3. Explain working of RTD. May/June08
4. What are strain gauges? May/June2010
5. Explain the Electrical transducers and selecting a transducer? Dec/Jan2008
6. Explain the Resistive transducer and Resistive position transducer? June/July2009
7. Explain the Thermistor Resistance thermometer? Dec/Jan2008
8. Explain the Inductive transducer? May/June2010
9. Explain the Differential output transducers and LVDT?

11. Briefly explain the working of LVDT used in displacement measurements. Why is a phase sensitive detector employed along with the LVDT
    Jan/ Feb -2004,2005, 2010, July/Aug-2010
12. What is a transducer? Briefly explain the procedure for selecting a transducer?
    Jan/ Feb 2012,Jan/ Feb -2009,2010, July/Aug-2004,2010
13. Briefly explain photoconductive and photovoltaic cells?
    Jan/ Feb -2009,2010, July/Aug-2004,2009,2010
14. What is the principle of electric resistance strain gauge? Derive an expression for the gauge factor in terms of the Poisson's ratio
    July/Aug-2005, July/Aug-2010
15. Explain the principle of displacement measurements using two differential transformers in a closed loop servo system July/Aug-2005
16. Explain the principle of operation of LVDT in translating a linear motion into an electrical signal Jan/ Feb -2006,2008,2011
17. What are the advantages and disadvantages of LVDT?
    Jan/ Feb -2006, Jan/ Feb -2009
18. Explain the classification of electrical transducers
    Jan/ Feb -2007, July/Aug-2006 , Jan/ Feb 2012
19. What is the principle of electric resistance strain gauge? Explain the unbounded resistance wire strain gauge Jan/ Feb -2007
20. Explain the operation of a LVDT and anyone application of it
    July/Aug-2007
21. Explain the advantage of electric transducer. Also describe the classification of transducer Jan/ Feb -2008
22. Differentiate between a sensor and a transducer? What are the factors affecting the choice of transducers? July/Aug-2008
23. Explain the principle and working of LVDT July/Aug-2008
24. Explain the classification of transducers with the help of examples
    July/Aug-2009

25. Derive the expression for gauge factor for a strain gauge
July/Aug-2008
26. Explain the classification of transducers with the help of examples
July/Aug-2009
27. What is a transducer? Briefly explain the photoconductive and photovoltaic cells
Jan/ Feb -2011, Jan/ Feb 2012

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In digital instruments, the output device of the instrument indicate the value of measured quantity using the digital display device. This digital display device may receive the digital information in any form but it converts the information in decimal form. Thus the digital display device indicates the value in decimal digits directly. The basic element in a digital display is the display for a single digit. By grouping such displays for single digits, we can get multiple digit display. In general, digital display is classified as planar and non-planar display. A planar display is a display in which entire characters are displayed in one plane. A non-planar display is a display in which characters are displayed in different planes. In this chapter we will discuss different display dl:\'ices. In general, LED's are most commmonly used in the digital displays. The LED's have advantages such as low voltage, long life, high reliability, low cost, fast swi~ching characteristics.

Display devices

In the digital electronic field, the most commonly used displays include cathode ray tube (CRT), light emitting diode (LED) and liquid crystal display (LCD), gas discharge plasma displays, electro-luminescent displays, incandescent displays.. liquid vapour displays etc.

A] Classification on the basis of conversion of electrical signal into the visible light :

There are two types of such displays.

a) **Active Displays** - CRT, gas discharge plasma display, LED

b) **Passive Displays** - LCD, electrophoretic image displays

B] Classification on the basis of applications :

a) **Analog Displays** - Bar graph display, CRT

b) **Digital Displays** - Nixie tubes, alphanumeric display, LED.

C] Classification on the basis of physical dimensions and sizes :

a) **Symbolic Displays** - Alphanumeric, Nixie tube, LED

b) **Console Displays** - LED, CRT

c) **Large Screen Displays** - Enlarged projectors

D] Classification on the basis of display format

a) **Direct View Type (Flat Panel)** - Segmental display, dot matrix

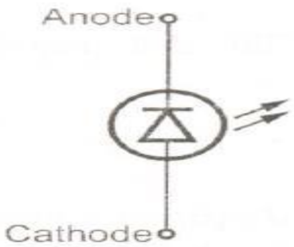
b) **Stacked Non-planar Type** - Nixie tube

E] Classification on the basis of resolution

a) Simple single element indicator

b) Multielement displays

LED

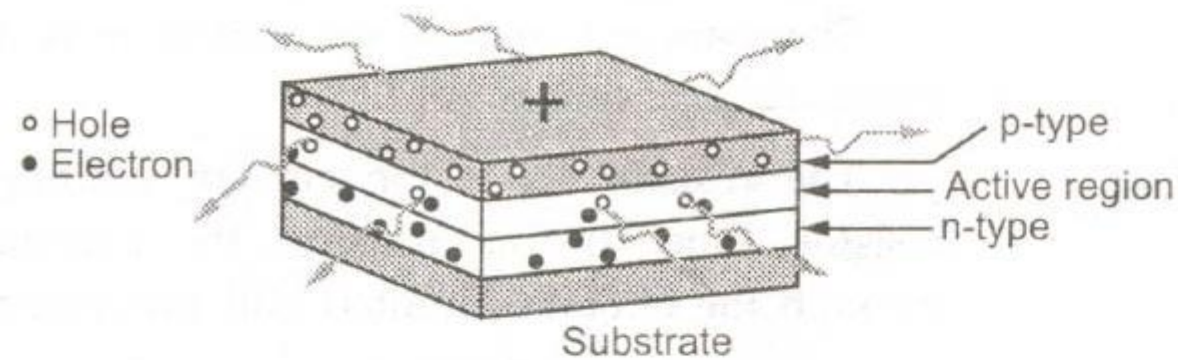


The LED is an optical diode, which emits light when forward biased. The Fig. shows the symbol of LED which is similar to p-n junction diode apart from the two arrows indicating that the device emits the light energy.

Basic Operation:

p-n junction is forward biased, the electrons cross the p-n junction from till' 11 type semiconductor material c1nd recombine with the holes in the p type "ellliconductor material. The free electrons are in the conduction band while the holes are prl'"ent in the valence bcllld. Thus the free electrons are at higher energy level with respect to the holes. When a free electron recombines with hole, it falls from conduction band to a valence band. Thus the energy level associated with it changes from higher value to lower value. The energy corresponding to the difference between higher level and lower level is released by an electron while traveling from the conduction band to the valence band. In *diodes, this* energy released is in *the* form of neat. 5ut LED j·s made up some special material which release this energy in the form of photons which emit the light energy. Hence such diodes are called light emitting diodes.

Construction of LEDs:



One of the methods used for the LED construction is to deposite three semiconductor layers on the substrate as shown in the Fig In between p type and n type, there exists an active region.

LED Driver Circuit

The output of a digital circuit is logical i.e. either'O' or '1'. The '0' means low while '1' means high. In the high state the output voltage is nearly 5 V while in low state, it is almost 0 V. If LED is to be driven by such digital circuit, it can be connected as shown in the Fig. 10.10. When output of digital circuit is high, both ends of LED are at 5 V and it can not be forward biased hence will not give light. While when output of digital circuit is *!nw,* then high current will flow through LED as it becomes forward biased, and it will give light.

To improve the brightness of display, a dynamic display system is used. In thIS, the LEOs are not lit continuously but are sequentially lit by scanning in a "vertical strobe" or "horizontal strobe" mode. This is similar to "running lights" used Jl1 modern advertisements. In the vertical strobe mode, a single row is selected at a time, the appropnatp LEOs are energized in that row, and then the signal is applied to next row. On the contrary, in horizontal strobe mode, a single column is selected at a time.

Alphanumenc displays using LEOs employ a number of square and oblong emitting areas, arriJnged either as dot matrix or segmented bar matrix. Alphanumeric LEOs are normally laid out on a single slice of semiconductor material, all the chips being enclosed in a package, similar to an IC, except that the packaging compound is transparent, and not opaque

Liquid Crystal Displays (LCDs)

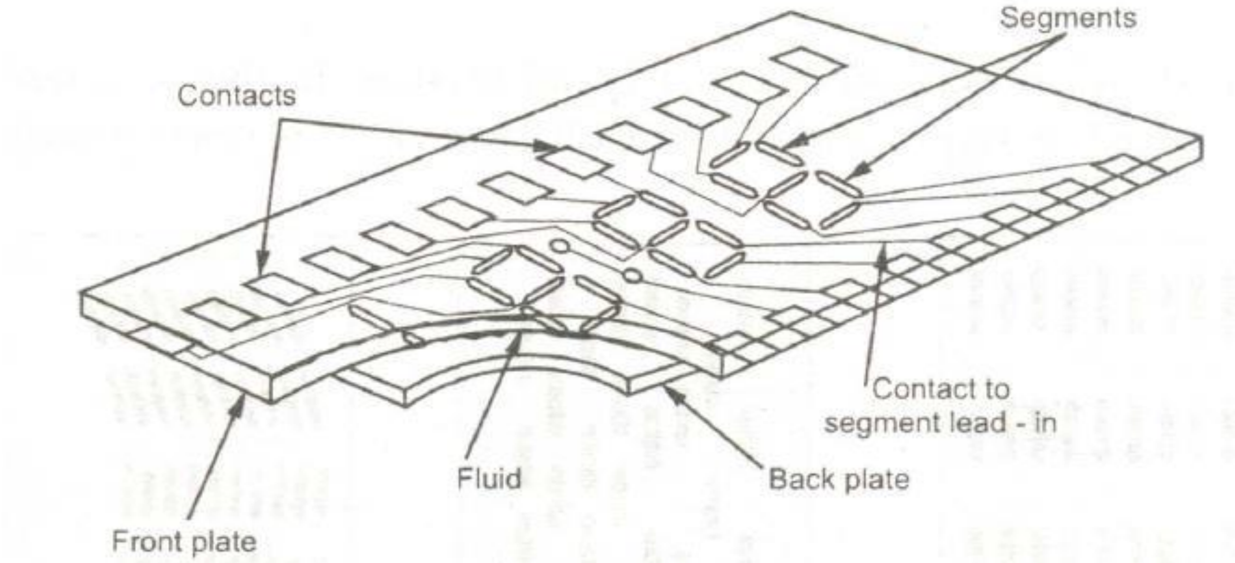
The liquid crystals are one of the most fascinating material systems in nature, having properties of liquids as well as of a solid crystal. The terms liquid crystal refers to the fact that these compounds have a crystalline arrangement of molecules, yet they flow like a liquid. Liquid crystal displays do not emit or generate light, but rather alter externally generated illumination. Their ability to modulate light when electrical signal is applied has made them very useful in flat panel display technology. The crystal is made up of organic molecules which are rod-like in shape with a length of -20 A ° - 100 A 0. The orientation of the rod like molecule defines the "director" of the liquid crystal. The different arrangements of these rod-like 'molecules leads t(three main categories of liquid crystals.
1.Smectic 2. Nematic 3. Cholesteric

Types of LCDs

There are two types of liquid crystal displays (LCDs) according to the theory of operation:
1. Dynamic scattering 2. Field effect.

Dynamic Scattering Type LCD

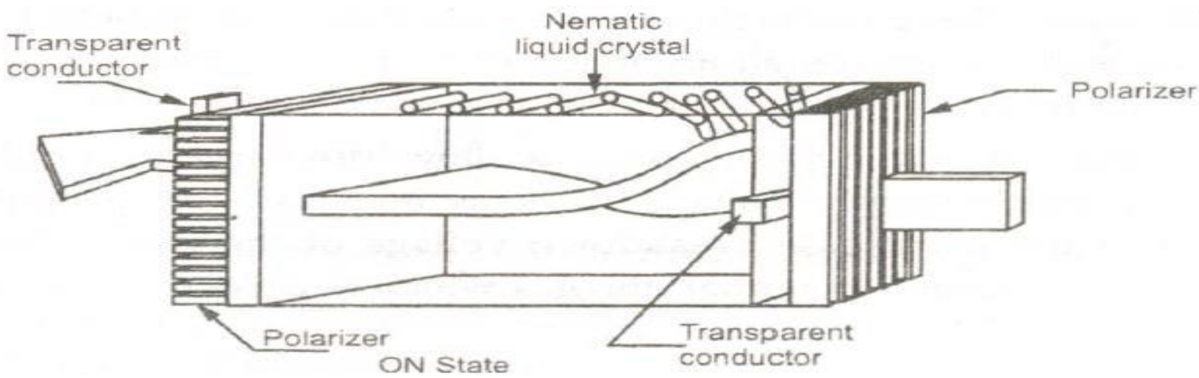
Fig. shows the construction of a typical liquid crystal display. It consists of two glass plates with a liquid crystal fluid in between. The back plate is coated with thin transparent layer of conductive material, where as front plate has a photoetched conductive coating with seven segment pattern as shown in Fig



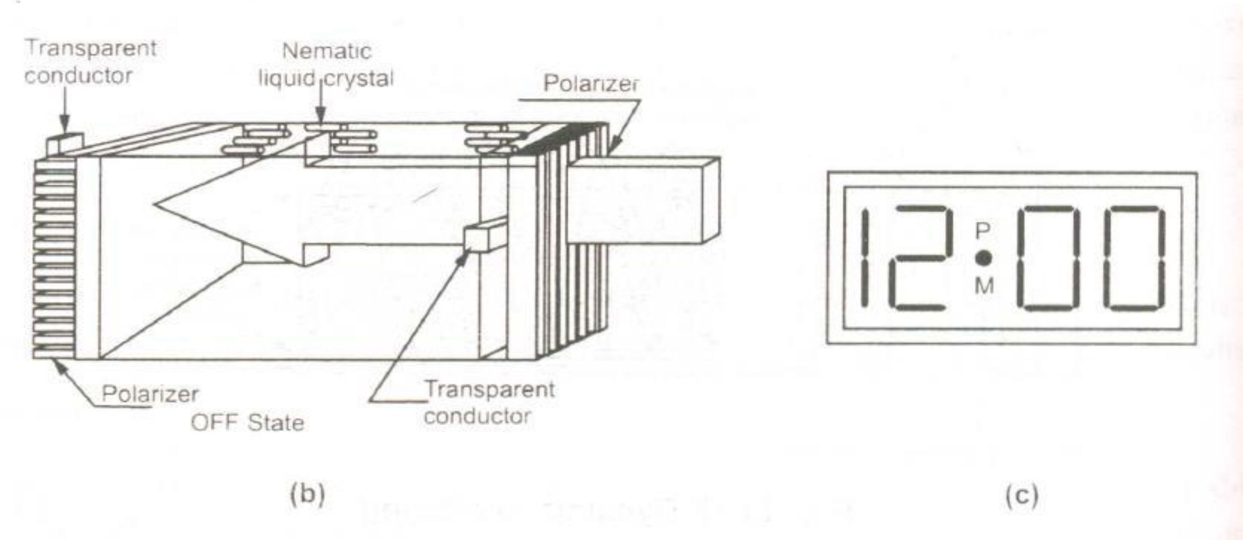
Field Effect Display

In these displays nematic liquid crystals are used. Fig shows operation of field effect liquid crystal display with pneumatic crystals. It consists of two glass plates, a liquid crystal fluid, polarizer and transparent conductors. The liquid crystal fluid is sandwiched between two glass plates. Each glass plate is associated with light polarizer. The light polarizer is placed at right angle to each other. In the absence of electrical excitation, the light coming from the front polarizer is rotated through/-O" in the fluid and passed through the rear polarizer. It is then reflected to the viewer by the back mirror as shown in Fig. (a).

On the application of electrostatic field, the liquid crystal fluid molecules get aligned and therefore light through the molecules is not rotated by 90° and it is absorbed by the rear polarizer as shown in Fig. (b). This causes the appearance of dark digit on a light background as shown in Fig. (c).



(a) Field effect display "ON state"



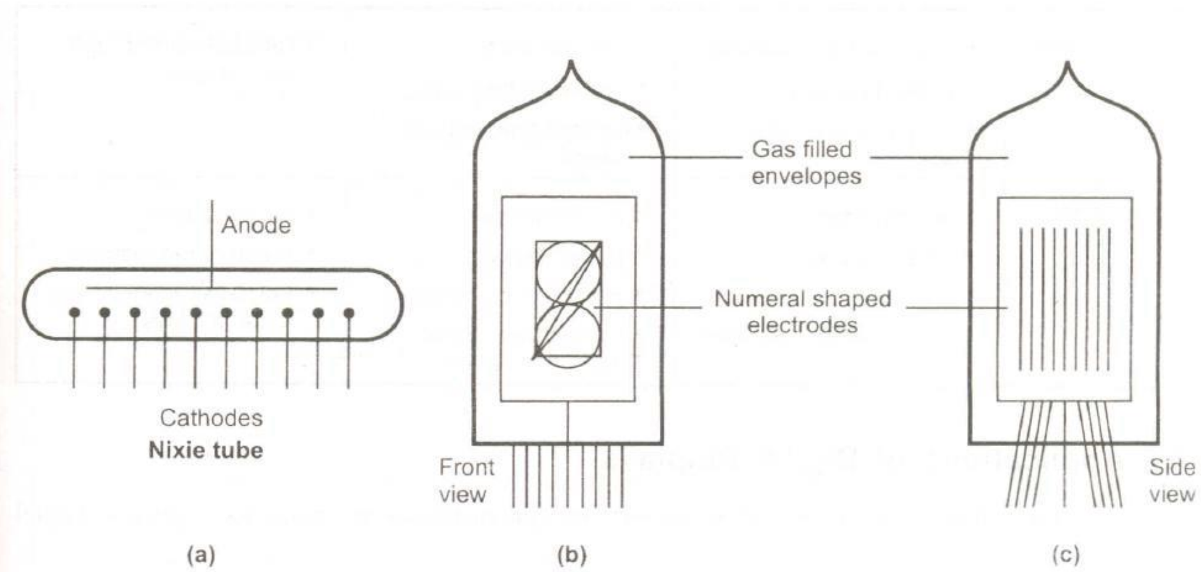
Advantages of LCDs

1. Less power consumption
2. Low cost
3. Uniform brightness with good contrast

Nixie tubes

The operation of this display is based on the principle that under breakdown condition, a gas near cold cathode gas filled tube emits light. The cold cathode indicators <Ire called Nixie Tubes. These are based on the principle of glow discharge in a cold cathode gas filled tubes. The construction of the nixie tube is as shown in the Fig. It consists of 10 cathodes and one anode; all are made of thin wires. But only difference is anode is in the form of thin frame.

When a gas near the cathode breaks down, a glow discharge is produced. The gauze electrodes with a positive supply voltage work as an anode. In general this voltage is selected greater than the worst case breakdown voltage of the gas within tube. When the cathode is connected to ground potential, the gas which is close to a cathode glows.



Data Acquisition system

Introduction

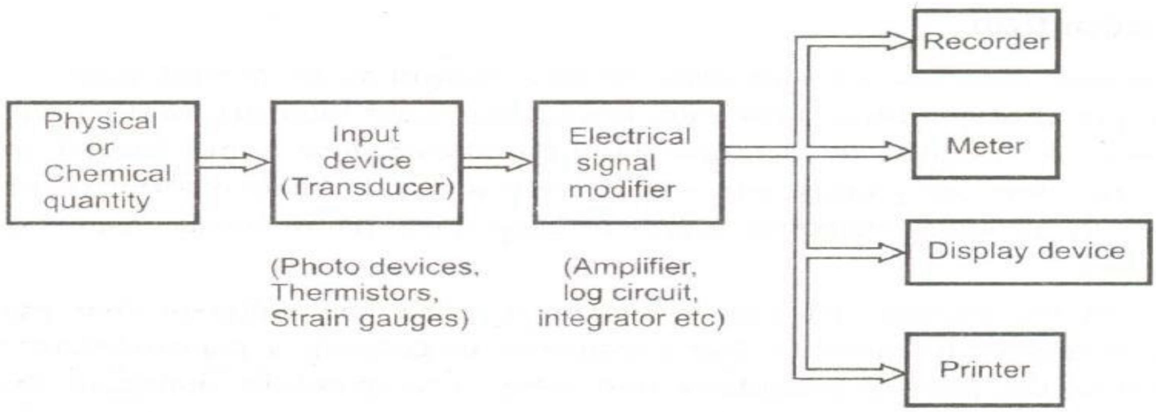
The primary objective of industrial process control is to control physical parameters such as temperature, pressure, flow rate, level, force, light intensity, and so on. The process control system is designed to maintain these parameters near some desired specific value. As these parameters can change either spontaneously or because of external influences, we must constantly provide corrective action to keep these parameters constant or within the specified range.

To control the process parameter, we must know the value of that parameter and hence it is necessary to measure that parameter. **In** general, a measurement refers to the transduction of the process parameter into some corresponding analog of the parameter, such as a pneumatic pressure, an electric voltage, or current. A **transducer** is a device that performs the initial measurement and energy conversion of a process parameter into analogous electrical or pneumatic information. Many times further transformation or signal enhancement may be required to complete the measurement function. Such processing is known as **signal conditioning.**

Data aided measurement:

For any measurement system., the first stage detects the physical quantity to be this is done with the help of suitable transducer. The next stage converts this signal into an electrical form. The second stage is used to amplify the converted signal such that it becomes usable and suitable for the last stage which is signal conditioning stage. The last stage includes various elements used for different purposes such as indicating, recording, displaying, data processing and control elements.

A typical electronic aided measurement system is as shown in the below Figure.

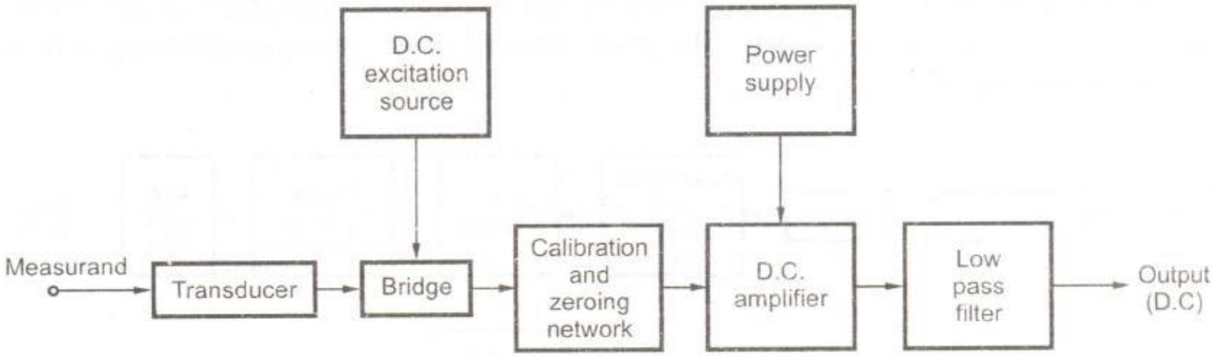


The first stage is the input device which is nothing but a transducer which converts measured into an usable form i.e. electrical signal. In other words, the quantity measured is encoded as an electrical signal. The next stage modifies the electrical signal in the form suitable for the output or read-out devices. Generally the most frequently used electronic circuits are amplifiers, with parameter adjustments and automatic compensation circuits specially used for temperature variation. of the input device and non-linearity's of the input device. The output is obtained from read-out devices such as meter, recorder, printer, display units etc. In general, the quantity which is measured by using transducer can be encoded in different ways. For example, as a physical or chemical quantity or property, as a
characteristics of the electrical signal, as a number. The property or different characteristics used to represent a data is called **data** domain.

The electronic aided measurement system represents the measurement of physical quantity faithfully in the analog or digital form of it obtained from the signal conditioning circuits. For passive transducers, the signal conditioning circuit mainly' includes excitation and amplification circuitry, while for active transducers, only amplification circuitry is needed and the excitation is not needed. Depending on the type of the excitation either a.c. or d.c. source, we have a.c. signal conditioning system and d.c. signal conditioning system.

D.C. Signal Conditioning System

The block diagram of d.c. signal conditioning system is shown in the Fig



The resistance transducers are commonly used for the d.c. systems. The resistance transducers like strain gauge forms one or more arms of a Wheatstone bridge circuit. A separate d.c. supply is required for the bridge. The bridge is balanced using potentiometer and can be calibrated for unbalanced conditions. This is the function of Calibration and zeroing network. Then there is d.c. amplifier which also requires separate d.c. supply.

The d.c. amplifier must have following characteristics:

1. Balanced differential inputs.
2. High common mode rejection ratio. (CMRR)
3. Hlgh input impedance.
4. Good thermal and long term stability.

The d.c. system has following advantages:

1. It is easy to calibrate at low frequencies.
2. It is able to recover from an overload condition.

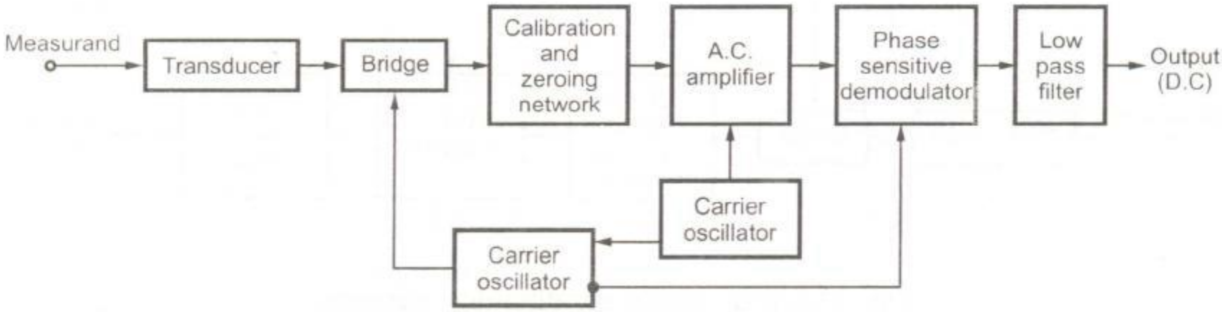
But the main disadvantage of d.c. system is that it suffers from the problems of drift. he low frequency spurious unwanted signals are available along with the required data signal. For overcoming this, low drift d.c. amplifiers are required.

The output of d.c. amplifier is given to a low pass filter. The function of low pass filter s to eliminate unwanted high frequency components or noise from the required data signed. Thus the output of low pass filter is the required data signal. Thus the output of low pass filter is the required d.c. output from the d.c. signal conditioning system.

The applications of such system are in use with common resistance transducers such as potentiometers and resistance strain gauges.

A.C. Signal Conditioning System

The limitation of d.c. signal conditioning system can be overcome upto certain extent, sing a.c. signal conditioning system. The block diagram of a.c. signal conditioning system as shown in the Fig



This is carrier type a.c. signal conditioning system. The transducer used is variable resistance or variable inductance transducer. The carrier oscillator generates a carrier signal of the frequency of about 50 Hz to 200 kHz. The carrier frequencies are higher and are altleast 5 to 10 times the signal frequencies.

The bridge output is amplitude modulated carrier frequency signal. The a.c. amplifier is used to amplify this signal. A separate power supply is required for the a.c. amplifier. The amplified signal is demodulated using phase sensitive demodulator. The advantage of using phase sensitive demodulator is that the polarity of d.c. output indicates the direction of the parameter change in the bridge output.

Unless and until spurious and noise signals modulate the carrier, they will not affect the data signal quality and till then are not important. Active filters are used to reject mains frequency pick up. This prevents the overloading of a.c. amplifier. Filtering out of carrier frequency components of the data signal is done by phase sensitive demodulator.

The applications of such system are in use with variable reactance transducers and for the systems where signals are required to be transmitted through long cables, to connect the transducers to the signal conditioning system further processing of signals is required which includes linear and nonlinear operations This type of signal conditioning includes the circuits like sample and hold, multiplexers, analog to digital converters etc.

Questions:

1. Discuss different considerations of power measurement in various frequency ranges. Dec09/June2010
2. Explain briefly the techniques used for power measurement at high frequencies. June/July2009, Jan/ Feb 2012
3. Write a note on power measurement at audio frequency.
4. What are basic requirements of load 7 Write different forms of the dummy load satisfying above requirements. Dec09/June2010
5. Explain R.F. power measurement.
6. Write notes on :1) data acquisition systems. May/June2010, Jan/ Feb 2012
7. Explain power measurement using Draw l1eat schematic diagram.
8. Explain power measurement using unbalanced bolometer bridge. June/July2009
9. What is meant by signal conditioning? Will! is it necessary ? Dec/Jan2009
10. Write n node on data aided measurement system.
11. Explain d.c. signal conditioning system with the help of block diagram. Dec/Jan2009
12. Draw block diagram of signal conditioning system. Explain briefly. May/June2010
13. Explain with block diagram , the essential functional operations of a digital data acquisition system. Compare the digital and analog forms of data acquisition systems Jan/ Feb -2004,2005, July/Aug-2004, Jan/ Feb 2012
14. Explain with block diagram the essential functional operation of a digital data acquisition system Jan/ Feb -2007,2009,2010, July/Aug-2006,2008,2009,2010
15. Explain the interfacing of frequency counter with IEEE – 488 BUS with the help of a block diagram Jan/ Feb -2004,2005,2007, Jan/ Feb 2012
16. Write a note on digital to analog multiplexing July/Aug-2004,2005
17. Explain the timing relationship of signal in a IEEE-488 bus July/Aug-2005, 2006
18. Briefly discuss on the instruments used in computer controlled instrumentation July/Aug-2005
19. Explain the working of IEEE 488 electrical interface towards testing of computer controlled instrumentation system Jan/ Feb -2006
20. What is the function of instrumentation amplifier? What are its characteristic features? Jan/ Feb -2011, July/Aug-2007
21. Briefly explain the instruments used in computer controlled instrumentation

July/Aug-2007, Jan/ Feb 2012

22. Write short notes on the following (a) objective of DATA acquisition system (b)LCDdisplay Jan/ Feb -2008
23. With a neat sketch, explain the working of a X-Y Recorder Jan/ Feb -2008,2010.2011, July/Aug-2008,2009,2010
24. Write short note on LCD display Jan/ Feb -2008
25. Write short note on the various display devices viz. LED, LCD, Nixie tube July/Aug-2008
26. Explain the classification of displays July/Aug-2009
27. write a note on LED and LCD display July/Aug-2010
28. Explain the working of signal generator with the help of neat diagram Jan/ Feb -2010, July/Aug-2009

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