

BEE306B:Electrical Measurements and Instrumentation



Course Objective :

- To understand the significance and method of measurement, elements of generalized 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.

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 generalized 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, magnetizing 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, Nixies, Incandescent, Fluorescent, Liquid vapor 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 Outcomes

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

- CO1: Explain** the significance and methods of Measurements, elements of generalized measurement system and errors in measurements. (L2)
- CO2: Identify** the suitable bridges to Measure resistance, inductance and capacitance by different methods. (L3)
- CO3: Explain** the construction, working and characteristics of various instrument transformers. (L3)
- CO4: Summarize** the working of different electronic instruments and display devices. (L2)

Reference Books:

- 1. Electrical and Electronic Measurements and Instrumentation, R.K. Rajput, S Chand, 5th Edition, 2012**
- 2. Electrical Measuring Instruments and Measurements, S.C. Bhargava, BS Publications, 2013**
- 3. Modern Electronic Instrumentation and Measuring Techniques, Cooper D and A.D. Heifrick, Pearson, First Edition, 2015**
- 4. Electronic Instrumentation and Measurements, David A Bell, Oxford University, 3rd Edition, 2013**
- 5. Electronic Instrumentation, H.S.Kalsi, Mc Graw Hill, 3rd Edition, 2010**

CIE :

1. For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks. But test will be conducted for 40 marks and average of best of two will be considered.
2. The first test will be administered after 40-50% of the syllabus has been covered
3. second test will be administered after 85-90% of the syllabus has been covered
4. Any two assignment methods, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
5. For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

Measurement to Day- Day

1. Foot and handspan are **non standard , non uniform units** of measurement larger and smaller in hands and feet
2. Similarly ,measurement of an any object using paper clips and a straw are an example for **Non standard and uniform units** of measurement.
3. 4 level of measurements are

Nominal scale: customer survey ask which brand do you performed Samsung,iphone,vivo ,nokia this case only names or brands are significant for researcher not any order ,Gender specify the category not an order.

2nd level measurement : ordinal Scale: ex : hot , hotter, hottest which had a definite order with nominal features

3rd level of measurement : Interval Scale : A space in between Ex..Temperature Celsius 20degree is not twice as hot as 10 degree C.

4th level of measurement Ratio Scale : height of 2 people weight age

Measurement: It is the act, or the result of quantitative comparison between a predetermined std. and or an unknown magnitude. Since two quantities are compared and the result are expressed in numerical value.

Measurand: The physical quantity or the characteristic conditions which is the object of measurement in an instrumentation system is termed as measurand or measurement variable or process variable.

e.g. Fundamental Quantity: length, mass, time et.

Derived Quantity : Speed, Velocity, Pressure etc.



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

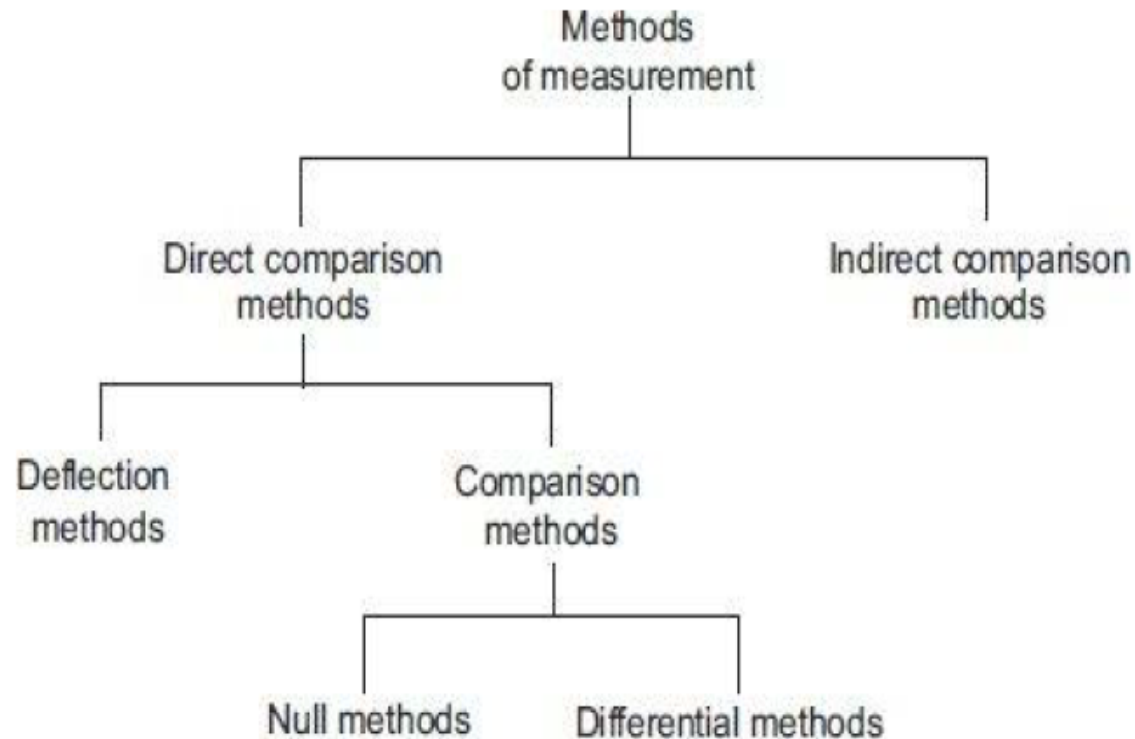
“When you can measure, what you are speaking and express it in numbers, you know something about and can express it in numbers, you know something about it, when you cannot express in it numbers in knowledge is of meagre and unsatisfactory kind” – Lord Kelvin

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



Methods of Measurement

Method of Measurement

Direct Method

The unknown quantity (measurand) is directly compared against a standard. The result is expressed as a numerical number and a unit. Direct methods are common for the measurement of physical quantities like length, mass and time

Indirect Method

In this method the comparison is done with a standard through the use of a calibration s/m. These methods are used those cases where the desire parameter to be measured. E.g. Acceleration, power

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.

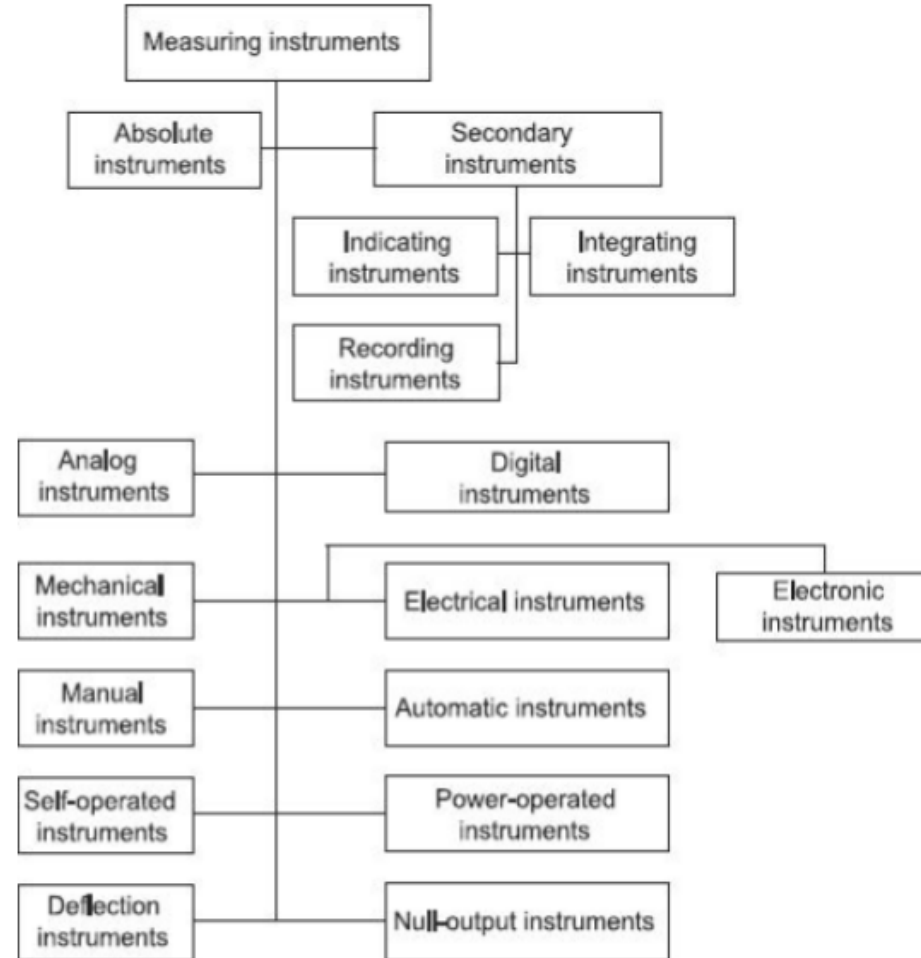
➤ Scientific instruments used three essential elements as our modern instruments these elements are

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
3. Electronics Instrument

CLASSIFICATION OF INSTRUMENTS



Mechanical instruments:

- The mechanical instruments are mainly used for measuring physical quantities.
- This instrument is suitable for measuring the static and stable conditions, because these instruments are 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 have quick response time and are more rapid compared to mechanical instruments.
- Unfortunately, electrical systems depend on mechanical meter movement as indicating devices, and mechanical movement has 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 therein 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**

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.

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

1 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.

Absolute or Primary/Secondary Instruments

Absolute Instruments

- ☐ It gives the magnitude of quantity under measurement in terms of physical constants of the instrument e.g. Tangent Galvanometer
- ☐ In this type of instruments no calibration or comparison with other instruments is necessary.
- ☐ They are generally not used in laboratories and are seldom used in practice by electricians and engineers.



Secondary Instruments

- ☐ These instruments are so constructed that the quantity being measured can only be determined by the output indicated by the instrument.
- ☐ These instruments are calibrated by comparison with an absolute instrument or another secondary instrument, which has already been calibrated against an absolute instrument. e.g. Ammeter, Voltmeter etc.

Direct measuring instruments: These instruments convert 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.

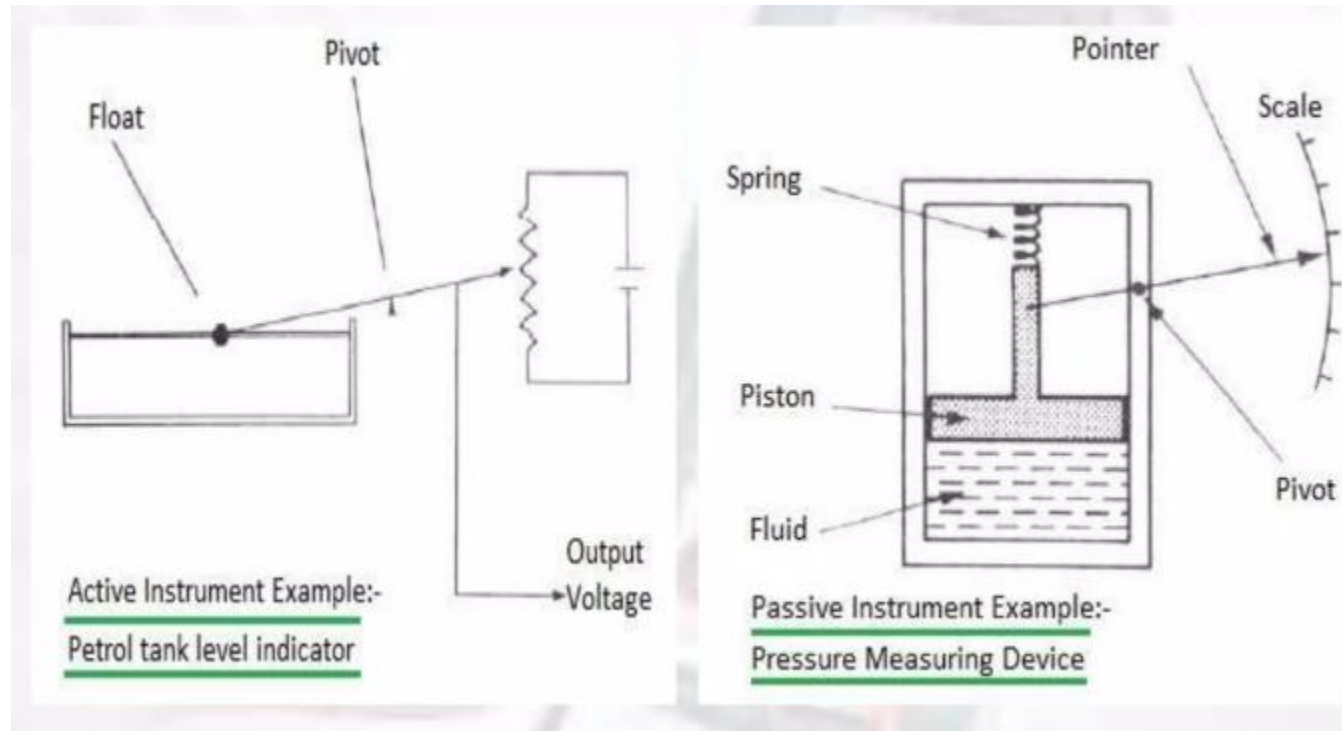
• **Comparison instruments:** These instruments measure the unknown quantity by comparison with a standard. Examples are dc and ac bridges and potentiometers. They are used when a higher accuracy of measurements is desired.

3. Analog and Digital Instruments:

Analogue Instruments: The signal of an analog unit varies 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.g. timer on a score board, odometer of an automobile.

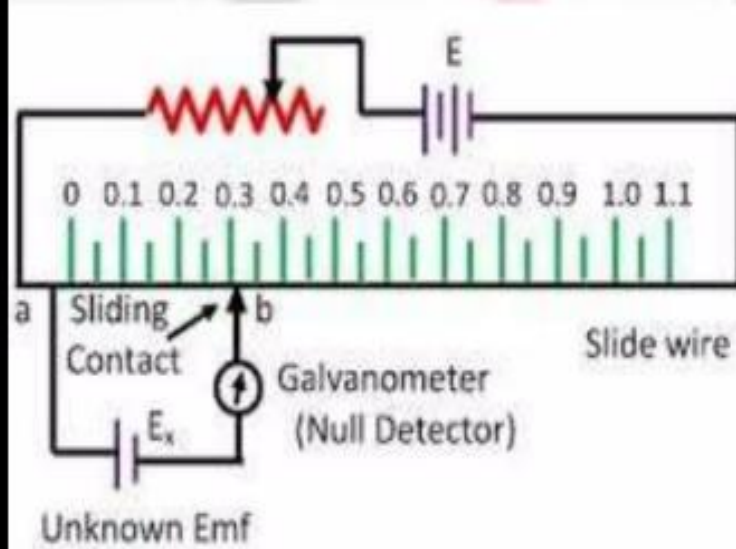
6. Active and Passive Instruments



7. Deflection and Null type instruments:

Deflection

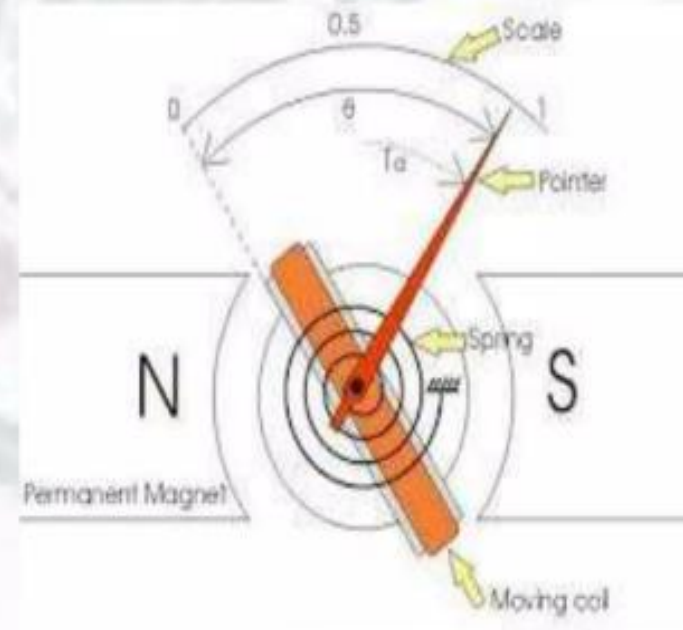
- Only one source of input reqd.
- Output reading is based on the deflection from the initial condition of the instrument
- The measurand value of the qty. depends on the calibration of the instrument



Circuit Globe

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

- Deflecting torque (T_d)** : 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
- Controlling torque (T_c)** : 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

