



Unit:- 01

Measurement

Date:- 27/11/24

Day:- Wednesday

Purpose of Measurement

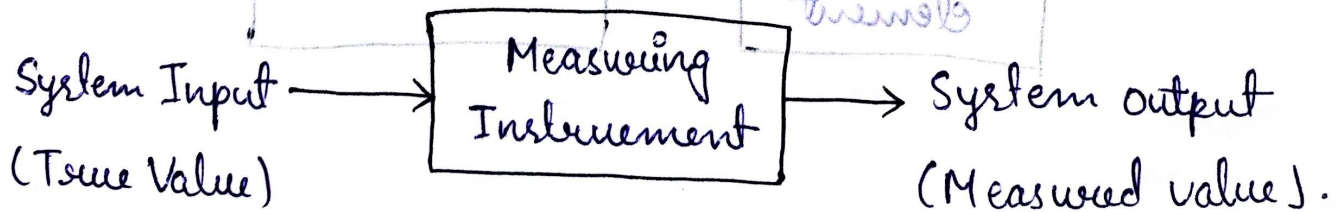
The purpose of measurement is to present measures value to numerical values.

→ Difference between measured value and true value?

Measured value :- Any value of or any reading calculates from measurement system or measuring instrument is known as measured values.

True values :-

Any value calculated from rated values is known as true values.



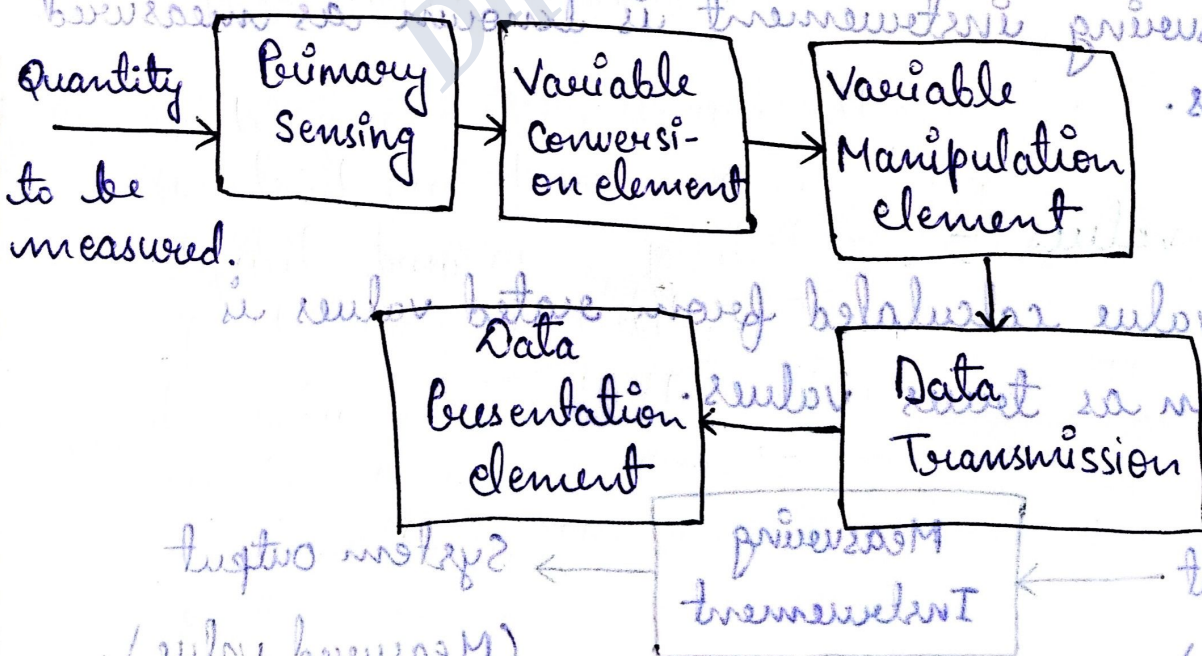
What is Measurement?



- * Measurement tell us about property of something.
- * Measurement provide us with a means of describing various phenomena in quantitative terms.
- * Measurement is the process by which we can convert physical parameters to meaningful numbers.
- * Measurement are always made by using an instrument (tool) of some kind.

e.g:- Ruler, Thermometer, Stop watch.

→ Block diagram of Measurement System :-



Types of ERROR :-

Static Error :-



We know that the static error of an instrument is the difference between the expected value of a quantity and its value as obtained by measurement. Static errors are classified as gross error, systematic errors and random errors.

→ Types of error :-

- 1) Gross Error
- 2) Systematic Error
- 3) Random Error

1. Gross Error (human error)

These errors are also known as human errors. These errors are mainly due to human mistakes in reading or observational recording error.

Errors also occur due to improper adjustments of instruments. These errors are cannot be treated mathematically. These errors are impossible to eliminate completely, but one can minimize them. Some errors are easily detected while others may be elusive. One of the basic gross errors that occur frequently



is the improper use of an instrument. We can minimize the error by taking proper care in reading and recording the instrument parameter. Gross errors may be of any amount and therefore their mathematical analysis is impossible. However they can be avoided by two means.

1. Great care should be taken in reading and recording the data.
2. Two, three or even more readings should be taken for quantity under measurement.

It is always advisable to take large number of readings assures that no gross error has been committed.

2. Systematic Error :-

Such errors are errors that remain constant or change according to a definite law on repeated measurement of the given quantity. These errors can be evaluated and the influence on the results of measurement can be eliminated by the introduction of proper corrections.

→ These types of error is divided into three different categories:

- a. Instrument error
- b. Environmental error
- c. Observational error.

a) Instrumental error :-

These errors are inherent in instrument because of their mechanical structure.

They may be due to construction, calibration or operation of the instruments or measuring devices.

For example, in the D's Arsonval movement friction in the bearings of various moving components, irregular spring tensions, stretching of the spring or reduction in tension due to improper handling or overloading of the instrument. Other instrumental errors are calibration error causing the instrument to read high or low along its entire scale. It is possible to eliminate or at least reduce the instrumental errors by the following methods.

- i) Selecting a suitable instrument for the particular measurement application.
- ii) Applying correction factors after determining the instrumental errors.

iii) Calibrate the instrument once again against a standard.



b) Environmental Errors :-

Environmental errors are due to conditions external to the measuring device, including conditions in the area surrounding the instrument, such as temperature, pressure, humidity, dust, vibrations or of external magnetic or electrostatic fields.

These errors can be eliminated or reduce by taking the following precautions:

- i) Using instrument in controlled conditions of pressure, temperature and humidity in which it was originally assembled and calibrated.
- ii) If above is not possible then deviations in local conditions must be determined and suitable corrections to instrument readings applied.
- iii) Automatic compensation employing sophisticated devices for such deviations is also possible.
- iv) In case, it is suspected that external magnetic or electrostatic fields can affect



the readings of the instruments, magnetic or electrostatic shields may be provided.

c) Observational Error :-

Observational errors are introduced by the observer. There are many sources of observational errors.

The most common error is the parallax error introduced in reading a scale. To minimize parallax errors, highly accurate meters are provided with mirrored scale. Parallax errors arise on account of pointer and the scale not being in the same plane, we can eliminate this error by having the pointer and the scale in the same plane.

In general systematic errors can be subdivided into static or dynamic errors. Static errors are caused by limitations of the measuring device and dynamic errors are caused by the instruments not responding fast enough to follow the change in measured variable.

3) Random Error :- $A \pm \Delta A = A$

These errors are also due to unknown causes and occur when all systematic and gross errors have been substantially reduced or at least accounted for. These errors



are due to an accumulation of a large number of small effects and may be no real concern when measurement requiring a high degree of accuracy. Such errors are generally analyzed statistically.

→ Limiting Error :-

The relative error is defined as the ratio of the error to the specified magnitud.

In most indicating instruments the accuracy is guaranteed to a certain percentage of full-scale reading. Circuit components are guaranteed to be within certain percentage of rated value. The limits of these deviations from the specified value are defined as limiting errors.

Say the magnitude of a quantity having a nominal value A_s and limiting error of $\pm SA$

Actual value of Quantity

$$A_a = A_s \pm SA$$

Actual value lies between the limits $A_s - SA$ and $A_s + SA$.

Limiting error is variable.



For example, the nominal magnitude of a resistor is $4.7 \text{ k}\Omega$ with a limiting error of $\pm 10\%$. The magnitude of the resistance will be between the limits:

$$A_s = 4.7 \text{ k}\Omega \pm 10\%$$

$$\text{or, } A_s \geq 469 \Omega \text{ and } A_s \leq 4710 \Omega$$

→ Relative Limiting Error

The relative limiting error is defined as the ratio of the error to the specified magnitude of a quantity.

If Relative limiting error is E_r then

$$E_r = \frac{\delta A}{A_s} = \frac{e}{A_s} \quad [\because e = \text{absolute error}]$$

$$\therefore e = \delta A = E_r A_s$$

notes provided a for everyone to keep it a keep was so helpful (thank you) thanks all at everyone notes. thank you. please give so everyone all in

Date:- 02/12/24 Day:- Monday

The response of a measurement system due to a time varying input consists with two parts. $\Delta OI \pm \Delta X F.F = \Delta A$

1. Transient response.

2. Steady state response.

Dynamic characteristics

→ The dynamic behaviour of a measurement system depends on the following characteristics

1. Speed of response.

2. Fidelity

3. Dynamic error.

[$\text{measured value} = 9$:] $\frac{9}{2A} = \frac{AB}{2A} = 1.5$

1. Speed of Response :- $2A \cdot 1.5 = AB = 9$:

The speed of response of a measuring system (instrument) defined as how quick a measurement system responds to the change in the measured or input quantity.

2. Fidelity :-

Fidelity of a measurement system is defined as the degree at which a measurement system indicates the changes in the measured quantity without any dynamic error.

3. Dynamic error :-

Dynamic error of a measurement system is defined as the difference between the true value of the input quantity under measurement changing with time and the value indicated by the measurement system.

► Static Characteristics of an instrument.

Generalized electronic measurement system Block diagram.

Static characteristics of measurements refer to the performance attributes of an instrument when the measured quantity remains constant or changes very slowly. These characteristics are essential for assessing the accuracy and reliability of an instrument in steady-state conditions.

The Key Static Characteristics are :-

1) Accuracy :-

The degree to which the measured values agree with the true value. High accuracy minimizes errors in measurement.

2) Precision :-

The ability of the instrument to provide consistent measurements for the same input under unchanged conditions. Precision is related to the repeatability of the measurement.

3) Resolution :-

The smallest change in the input that an instrument can detect. Higher resolution means the instrument can detect finer variations in the measured quantity.

4) Sensitivity :-

The ratio of the change in output to the change in input. It indicates how responsive the instrument is to variations in the measured quantity.

5) Stability :-

The ability of an instrument to maintain its performance and accuracy over time.

6. > Repeatability :-

It means an instrument or system gives at the same measurement every time when tested, under the same conditions. It shows how reliable and consistent the measurements are.

7. > Error :-

Error is the difference between the true value and the value shown by an instrument. It shows how much the measurement is incorrect or off from the actual value.

► Necessity of Measurements :-

1. > Direct Method :-

The necessity of measurements using the direct method arises because it provides a simple and straight forward way to determine a quantity by directly comparing it with a standard.

For example, measuring length with a ruler or weight with a balance.

2. > Indirect Method :-

The indirect method of measurement is used when it is not possible or practical to measure a quantity directly. Instead, the desired value is determined by measuring related quantities and

using mathematical formulas or relationships to calculate the result.

► Sources of Error:

The sources of error, other than the ability of a piece of hardware to provide a true measurement are given below:

- 1.) Poor Design
- 2.) Change in process parameters, irregularities, upsets etc.
- 3.) Poor maintenance
- 4.) Certain design limitations.
- 5.) Insufficient knowledge of process parameters and design conditions.
- 6.) Errors caused by the person operating the instrument / equipment.

For example, measuring length with a scale or weight with a balance.

The indirect method of measurement is used when it is not possible or practical to measure directly. The indirect method involves measuring the quantity to be measured by measuring the quantities which are related to it.