Chapter 2 - Theory of Measurement

Error in Measurement:-

1. Absolute Error → The difference betn true value and measured value of any quantity is known as absolute Error.

$$\delta A = T.V - M.V$$

2. Relative Error → It can be defined as ratio of absolute Error to true value of any quantity.

$$Er = \frac{T.V - M.V}{T.V}$$

$$\% Er = \frac{T.V - M.V}{T.V} \times 100\%$$

3. limiting Error → The limit of deviation from specified value as mentioned by manufacturer of equipment.

For circuit component like Resistor, Inductor and capacitor. accuracy is express as percentage of rated value. For indicating instrument like voltmeter, Ammeter, accuray is express as a percentange of full scale reading.

For Eg, when a meter is said to be accurate to one percent of full scale reading this means a reading taken anywhere along its scale will not have an error more than 1% of full scale reading.

Types of Error :-

1. Gross Error :- All the error comitted by user are included in gross error such as reading error, calculation error, error in correction, error in placement, etc. Gross Error may be of any amount therefore their mathematical analysis is impossible.

Corrective measure of gross Error :-

- Take reading carefully.
- Connecting proper instrument in proper place.
- Take atleast three reading of same quantity preter by three different observer.

2. Systematic Error :- Error that remain constant or change according to definite law on repetate measurement of given quantity is called systematic error.

They are of two type :-

i) Instrumental Error → This error are due to :-

- Short coming of instrument.
- Deffective part of instrument.
- less accuracy in scale.
- poor construction.
- irregular spring tension.
- variation in air gap.
- misuse of instrument.

Corrective measure of instrumental error:

- Selecting standard instrument for particular measurement.
- Use correction factor.
- Recalibrate the instrument against standard instrument.

ii) Enviromental Error → All the error due to effect of surrounding such as error due to the variation in temperature, pressure, humidity, and external electrostatic and magnetic field. are included in enviromental error.

Corrective measures of Environmental Error:

- Perform the measurement in air-conditioned room to minimize the effect of variation in temp^{r}.
- use proper casing to minimized the effect of pressure and humidity.
- Use proper shielding to avoid the effect of external field.

3. Random Error :- This error are due to unknown causes and occur even all gross and systematic error have been accounted for.

Electronic noise in a circuit, often electrical instrument.

Irregular changes in the heat loss rate from a solar collector due to change in wind speed.

Corrective measure of Random Error:

- Apply statistical analysis only after minimizing gross and systematic error.
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Statistical Analysis :-

It is mainly concerned with precision of measurement and so it can't remove systematic error for set of data.

Terms used in statistical Analysis of data:

1. Arithimetic Mean ($\bar{X}$):- let $x_1, x_2, \ldots x_n$ be the reading taken and n be the no. of reading the arithimetic mean is given by,

$$\bar{X} = \frac{x_1 + x_2 + \ldots + x_n}{N}$$

$$\bar{X} = \frac{\sum_{i=1}^{N} x_i}{N}$$

2. Deviation from the mean (d): It shows the deviation of individual reading from the mean value i.e it shows how accurately and individual reading has been taken. But algebric sum of all the deviation is always zero. i.e $\sum_{i=1}^{N} d_i = 0$.

$$\left.\begin{aligned} d_1 &= x_1 - \bar{X} \\ d_2 &= x_2 - \bar{X} \\ &\vdots \\ d_N &= x_N - \bar{X} \end{aligned}\right\} \text{ — +ve, negative or zero.}$$

3. Average deviation (D): It gives an indication of the precession of the instrument used in measurement. low average deviation shows instrument used for measurement are highly precised. Average deviation can be expressed,

$$D = \frac{\sum_{i=1}^{N} |d_i|}{N}$$

4. Standard deviation :- It shows how much variation or disperson from the average exist also standard deviation indicate that the data points tends to be very close to mean. A high standard deviation indicate that the data points are spread out over a large range of value. So, reduction in standard deviation effectively means improvement in measurement. It can be expressed as,

$$\sigma = \sqrt{\frac{d_1^2 + d_2^2 + \ldots . dn^2}{n}} \quad , \text{ if } n > 20$$

$$s = \sqrt{\frac{d_1^2 + d_2^2 + \ldots + dn^2}{n-1}} \quad , \text{ if } n \leq 20$$

where, s = sample standard deviation
σ = population " "

5. Variance (v) :- It can be defined as square of standard deviation. It can be expressed as,

$$v = (\sigma)^2 = (s)^2$$

6. Gausian Probability curve :