Types of Errors

No measurement can be made with perfect accuracy, but its important to find out what the accuracy actually is , and who different errors have enter to the measurement, so study of errors is a first steps in finding ways to reduce them.

Errors may come from different sources and are usually classified under two main heading:

1- *Systematic Errors*

These types of errors have known reasons, and we can avoided, reduce or eliminated, and estimated it. These errors are subdivided into:

a) *Gross (Human) Errors*

- **i)** Misreading of instruments and observation errors.
- **ii)** Improper choice of instrument, or the range of instrument.
- **iii)** Incorrect adjustment or forgetting to zero.
- **iv)** Erroneous calculations, computation mistakes, and estimation errors.
- **v)** Neglect of loading effects.
- **vi)** Proper position for measuring human.

b) *Instrumentation (Equipment) Errors*

- **i)** Damaged equipment such as defective due to loading effect or worn parts.
- **ii)** Calibration errors.
- **iii)** Bearing fraction.
- **iv)** Component nonlinearities.
- **v)** Loss during transmission.
- **vi)** Proper position of equipment (vertical or horizontal).
- **vii)** Static charge error.

c) *Environmental Errors*

- **i)** Change in temperature, pressure.
- **ii)** Humidity.
- **iii)** Stray electric and magnetic fields.
- **iv)** Mechanical vibration.
- **v)** Weather variations (day, night, and four seasons).

d) *Measuring Errors*

Measuring human does not have enough efficiency and experience to expect the true measurement values and the reasons of errors.

2- *Random Errors*

Those due to causes that can not be directly established because of unknown events that causes small variation in measurement, quite random and unexplained. We can reduce this type of errors after treatment the systematic errors by taking many reading for the measuring value and apply statistical analysis to determine the best true estimate of measurement readings.

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Example (1):

(Systematic, Human errors, the proper range of measurement)

A 0 to 150V voltmeter has accuracy of 1% of full scale reading. The theoretical (true) expected value we want to measure it is 83V. Determine the practical (measured) value and the percentage of error.

Sol.:

Tolerance= accuracy x V_{FSD}

Tolerance= 1% x 150 = 0.01 x 150 = 1.5V

Measured value= true ± tolerance

Measured value= 83 ± 1.5

Measured value= 84.5V or 81.5V

The percentage error is:

$$errors = \frac{true - measured}{true} \times 100\%$$

$$error = \frac{|83 - 84.5|}{83} \times 100\% = 1.81\%, \text{ or } \quad error = \frac{|83 - 81.5|}{83} \times 100\% = 1.81\%$$

Or $error = \frac{|\pm Tolerance|}{True} \times 100\% = \frac{|\pm 1.5|}{83} \times 100\% = 1.81\%$

If we want to measured anther readings on the same range and determine the error, suggest we take true 60V, and 30V.

For 60V the error is:

$$error = \frac{|\pm Tolerance|}{True} \times 100\% = \frac{|\pm 1.5|}{60} \times 100\% = 2.5\%$$

And for 30V

$$error = \frac{|\pm Tolerance|}{True} \times 100\% = \frac{|\pm 1.5|}{30} \times 100\% = 5\%$$

So we can see that the error is increased as smaller voltage is measured, thus take the proper range for every measured value, the range that give big deflection on the pointer as possible.

Example (2):

(Systematic, Human errors, the difference between theoretical and practical instruments)

To measured unknown resistor by ammeter and voltmeter method. A voltmeter of sensitivity 1000Ω/V, connect in parallel with the resistor reads 100V on its 150V scale (range), while the series ammeter read 5mA. Calculate the apparent value of the resistor, actual value, and the error.

Sol.:

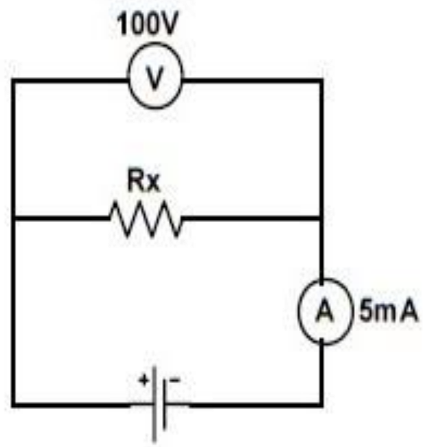
1- The apparent value of the resistor is:

$$R_{ap.} = \frac{V}{I} = \frac{100}{5mA} = 20K\Omega$$

2- The actual value of the resistor by taking the resistance of voltmeter in consider is:

$$R_V = 1000\frac{\Omega}{V} \times 150V = 150K\Omega$$

$$R_{act.} = \frac{R_{ap.} \times R_v}{R_v - R_{ap.}} = \frac{20 \times 150}{150 - 20} = 23.05K\Omega$$



3- The percent error is:

$$error = \frac{actual - apparent}{actual} \times 100\%$$

$$error = \frac{23.05 - 20}{23.05} \times 100\% = 13.22\%$$

Limiting Error

In most indicating instruments the accuracy is guaranteed to a certain percentage to a full scale reading. The limits of this deviation from the specified value are known as limiting errors or guarantee errors. For example, if the resistance of a resistor is given as 500Ω±10%, the manufacture guarantees that the resistance full between the limits 450Ω and 550Ω.

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