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DEPARTMENT OF BIOMEDICAL ENGINEERING

III Semester- BM3301 SENSORS AND MEASUREMENTS

UNIT -1

1.5 Errors in Measurements

Errors in measurements refer to the discrepancies or deviations between the measured value and the true value of a quantity being measured. These errors can arise due to various factors and can impact the accuracy and reliability of measurement results. Understanding different types of errors is essential for improving the quality of measurements and obtaining more accurate data. Here are some common types of errors in measurements:

1. Gross Errors.
2. Systematic Errors. (*Instrumental Errors, Environmental Errors, Observational Errors.)*
3. Random Errors.
4. Limiting Errors or Guarantee Errors.
5. Relative (Fractional) Limiting Error

1. Gross Errors:

Gross errors are significant and noticeable mistakes that lead to inaccurate measurements. They can result from human errors, malfunctioning equipment, or procedural mistakes. Gross errors are often easy to identify due to their significant impact on the measurement result.

Example, (i) the experimenter may, due to an oversight, read the temperature as 31.5°C while the actual reading may be21.5°C.

(ii) He may transpose the reading while recording. For example, he may read 25.8°C and record 28.5°C instead.

2. Systematic Errors

These types of errors are divided into three categories :

(i). Instrumental Errors.

(ii). Environmental Errors.

(iii). Observational Errors.

(i). Instrumental Errors:

These errors arise due to three main reasons :
(i) Due to inherent shortcomings in the instrument,
(ii) Due to misuse of the instruments, and
(iii) Due to loading effects of instruments.

Inherent shortcomings of instruments: These errors are inherent in instruments because of their mechanical structure. They may be due to construction, calibration or operation of the instruments or measuring devices. Example: For example, if the spring (used for producing controlling torque) of a permanent magnet instrument has become weak, the instrument will always read high.

Misuse of Instrument: Too often, the errors caused in measurements are due to the fault of the operator than that of the instrument.

Examples which may be cited for this misuse of instrument may be failure to adjust the zero of instruments.

Loading effects: One of the most common errors committed by beginners, is the improper use of an instrument for measurement work. For example, a well calibrated voltmeter may give a misleading voltage reading when connected across a high resistance circuit.

(ii) Environmental Errors:

These errors are due to conditions external to the measuring device including conditions in the area surrounding the instrument. These may be effects of temperature pressure, humidity, dust, vibrations or of external magnetic or electrostatic fields.

(iii) Observational Errors:

(a) There are many sources of observational errors. As an example, the pointer of a voltmeter rests slightly above the surface of the scale. Thus, an error on account of **PARALLAX** will be incurred unless the line of vision of the observer is exactly above the pointer.

We can eliminate this error by having the pointer and the scale in the same plane.

(b) The sensing capabilities of individual observers affect the accuracy of measurement. Different experimenters may produce different results.

Modem electrical instruments have digital display of output which completely eliminates these errors.

3. RANDOM (RESIDUAL) ERRORS:

The happenings or disturbances about which we are unaware are lumped together and called "Random" or "Residual". Hence the errors caused by these happenings are called Random (or Residual) Errors.

Since these errors remain even after the systematic errors have been taken care of, we call these errors as Residual (Random) Errors.

Example: -Electronic noise in the circuit of an electrical instrument,
-Irregular changes in the heat loss rate from a solar collector due to changes in the wind.

4. LIMITING ERRORS (GUARANTEE ERRORS) :

In most instruments the accuracy is guaranteed to be within certain percentage of full-scale reading. The manufacturer has to specify the deviations from the nominal value of a particular quantity. The limits of these deviations

from the specified value are defined as limiting errors or Guarantee errors. Thus the manufacturer has to specify the deviations from the nominal value of a particular quantity.

Example: the nominal magnitude of resistor is 10 Ω with a limiting error of 1, i.e. manufacturer guarantees that the value of resistance of the resistor lies between 9 Ω and 11 Ω.

5. RELATIVE (FRACTIONAL) LIMITING ERROR:

The relative (fractional) error is defined as the ratio of the error to the specified (nominal) magnitude of a quantity. Therefore,

In limiting errors, the specified quantity A_S is taken as the true quantity, and the quantity which has the maximum deviation from Aa is taken as the erroneous quantity. Thus, we have

$$\delta A = A_a - A_S$$

Relative limiting error, $E_r = \frac{A_a - A_s}{A_s}$

$$E_r = \frac{Actual\ Value - Nominal\ Value}{Nominal\ Value}$$

Source: A.K.Shawhney, "A Course in Electrical and Electronic Measurements and Instrumentation