

MEASUREMENT ERRORS

Introduction:

The measurement of any quantity plays very important role not only in science but in all branches of engineering, medicine and in almost all the human day to day activities.

The technology of measurement is the base of advancement of science. The role of science and engineering is to discover the new phenomena, new relationships, the laws of nature and to apply these discoveries to human as well as other scientific needs. The science and engineering is also responsible for the design of new equipments. The operation, control and the maintenance of such equipments and the processes is also one of the important functions of the science and engineering branches. All these activities are based on the proper measurement and recording of physical, chemical, mechanical, optical and many other types of parameters.

The measurement of a given parameter or quantity is the act or result of a quantitative comparison between a predefined standard and an unknown quantity to be measured. The major problem with any measuring instrument is the error. Hence, it is necessary to select the appropriate

measuring instrument and measurement procedure which minimises the error. The measuring instrument should not affect the quantity to be measured.

An electronic instrument is the one which is based on electronic or electrical principles for its measurement function. The measurement of any electronic or electrical quantity or variable is termed as an electronic measurement.

Advantages of Electronic Measurement

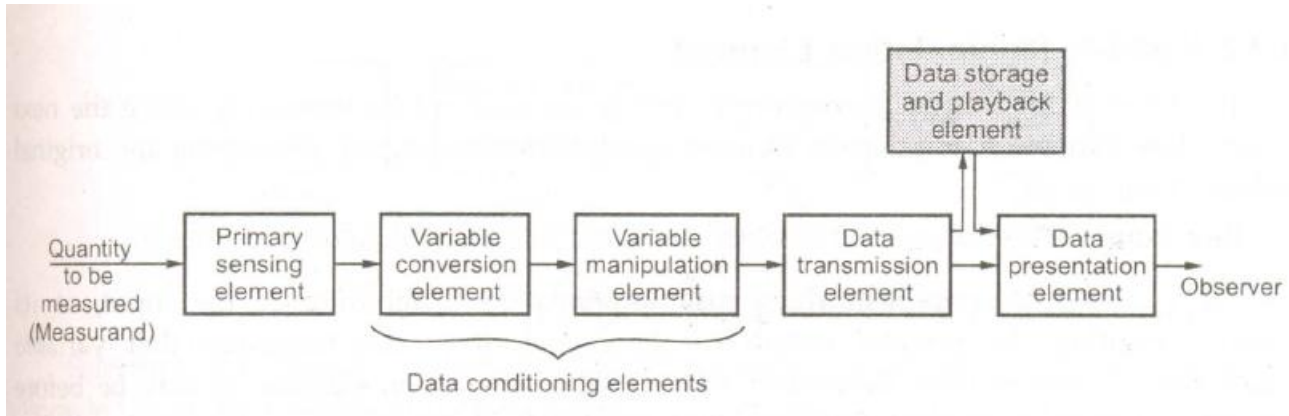
The advantages of an electronic measurement are

1. Most of the quantities can be converted by transducers into the electrical or electronic signals.
2. An electrical or electronic signal can be amplified, filtered, multiplexed, sampled and measured.
3. The measurement can easily be obtained in or converted into digital form for automatic analysis and recording.
4. The measured signals can be transmitted over long distances with the help of cables or radio links, without any loss of information.
5. Many measurements can be carried either simultaneously or in rapid succession.
6. Electronic circuits can detect and amplify very weak signals and can measure the events of very short duration as well.
7. Electronic measurement makes possible to build analog and digital signals. The digital signals are very much required in computers. The modern development in science and technology are totally based on computers.
8. Higher sensitivity, low power consumption and a higher degree of reliability are the important features of electronic instruments and measurements. But, for any measurement, a well defined set of standards and calibration units is essential. This chapter provides an introduction to different types of errors in measurement, the characteristics of an instrument and different calibration standards.

Functional elements of an instruments:

Any instrument or a measuring system can be described in general with the help of a block diagram. While describing the general form of a measuring system, it is not necessary to go into the details of the physical aspects of a specific instrument. The block diagram indicates the necessary elements and their functions in a general measuring system. The entire operation of an

instrument can be studied in terms of these functional elements. The Fig. 1.1 shows the block diagram showing the functional elements of an instrument.



Calibration:

Calibration is the process of making an adjustment or marking a scale so that the readings of an instrument agree with the accepted and the certified standard.

The calibration offers a guarantee to the device or instrument that it is operating with required accuracy, under the stipulated environmental conditions. It creates the confidence of using the properly calibrated instrument, in user's mind. The periodic calibration of an instrument is very much necessary.

The calibration characteristics can be determined by applying known values of quantities to be measured and recording the corresponding output of the instrument. Such output values are then compared with the input, to determine the error. Such a record obtained from calibration is called calibration record. It is generally recorded in the tabular form. If it is represented in the graphical form, it is called calibration curve. Such a calibration record or calibration curve is useful to obtain the performance characteristics of an instrument. The performance of the instrument is not guaranteed by the calibration. It only indicates whether the performance of the instrument is meeting the accuracy and range specification or not. If the device has been repaired, aged, adjusted or modified, then recalibration is carried out.

Static characteristics:

As mentioned earlier, the static characteristics are defined for the instruments which measure the quantities which do not vary with time. The various static characteristics are accuracy, precision, resolution, error, sensitivity, threshold, reproducibility, zero drift, stability and linearity.

Accuracy:

It is the degree of closeness with which the instrument reading approaches the true value of the quantity to be measured. It denotes the extent to which we approach the actual value of the quantity. It indicates the ability of instrument to indicate the true value of the quantity. The accuracy can be expressed in the following ways.

1) Accuracy as 'Percentage of Full Scale Reading' : In case of instruments having uniform scale, the accuracy can be expressed as percentage of full scale reading.

For example, the accuracy of an instrument having full scale reading of 50 units may be expressed as $\pm 0.1\%$ of full scale reading. From this accuracy indication, practically accuracy is expressed in terms of limits of error. So for the accuracy limits specified above, there will be ± 0.05 units error in any measurement. So for a reading of 50 units, there will be error of ± 0.05 units i.e. $\pm 0.1\%$ while for a reading of 25 units, there will be error of ± 0.05 units in the reading i.e. $\pm 0.2\%$. Thus as reading decreases, error in measurement is ± 0.05 units but net percentage error is more. Hence, specification of accuracy in this manner is highly misleading.

2) Accuracy as 'Percentage of True Value' : This is the best method of specifying the accuracy. It is to be specified in terms of the true value of quantity being measured. For example, it can be specified as $\pm 0.1\%$ of true value. This indicates that in such cases, as readings get smaller, error also gets reduced. Hence accuracy of the instrument is better than the instrument for which it is specified as percent of full scale reading.

3) Accuracy as 'Percentage of Scale Span' : For an instrument, if a_m is the maximum point for which scale is calibrated, i.e. full scale reading and a_{min} is the lowest reading on scale. Then $(a_m - a_{min})$ is called scale span or span of the instrument. Accuracy of the instrument can be specified as percent of such scale span. Thus for an instrument having range from 25 units to 225 units, it can be specified as $\pm 0.2\%$ of the span i.e. $\pm [(0.2/100) \times (225 - 25)]$ which is ± 0.4 units error in any measurement.

4) Point Accuracy: Such an accuracy is specified at only one particular point of scale. It does not give any information about the accuracy at any other Point on the scale. The general accuracy of an instrument cannot be specified, in this manner. But the general accuracy can be specified by providing a table of the point accuracy values calculated at various points throughout the entire range of the instrument.

Source : <http://elearningatria.files.wordpress.com/2013/10/ece-iii-electronic-instrumentation-10it35-notes.pdf>