Electronic Measurements (1)

Measurements and Measurement Systems - Part 1

Dr. Nancy Alshaer

Department of Electronics and Electrical Engineering Tanta University

Course Objectives

"To provide students with a fundamental understanding of the concepts, principles, procedures, and the computations used by engineers and technologies to analyse, select, specify, design, and maintain modern instrumentation."

Text Books

- Purkait, Prithwiraj. Electrical and electronics measurements and instrumentation. McGraw-Hill Education, 2013. (https://www.technicalbookspdf.com/)
- U.A.Bakshi, A.V.Bakshi, and K.A.Bakshi, Electronic and Electrical Measuring Instruments and Machines, 1^{st} Edition, 2009.
- A.K. Sawhney, Electrical and Electronic Measurements and Instrumentation, Dhanpat Rai and Co, New Delhi, 19^{th} Edition, 2011. (https://easyengineering.net/measurements-and-instrumentation-books-nw/)

Lecture Contents

- Electronics versus electrical.
- Measurements definition and requirements.
- Significance of measurements.
- Measurement methods.
- Definitions of some static characteristics.
- Measurement of errors.

Electronics versus Electrical

- **Electrical:**
  Electric things are those deal with higher voltages, transformers, generators etc.
- **Electronics:**
  - Electronic things are those which use low voltages of magnitude (0-15 V), like IC.s.
  - The behaviour of electrons in a circuit is controlled by certain current/voltage.
  - There is no mechanical parts (switches, relays) or electro-magnetism (coils).

Measurements

- **Definition:**
  It is the act, or the result of quantitative comparison between a predetermined standard and or an unknown magnitude. Since two quantities are compared and the result are expressed in numerical value.
- **Requirements:**
  (1) The standard used for comparison purpose must be accurately defined and should be commonly accepted.
  (2) The apparatus used and the method adopted must be provable.

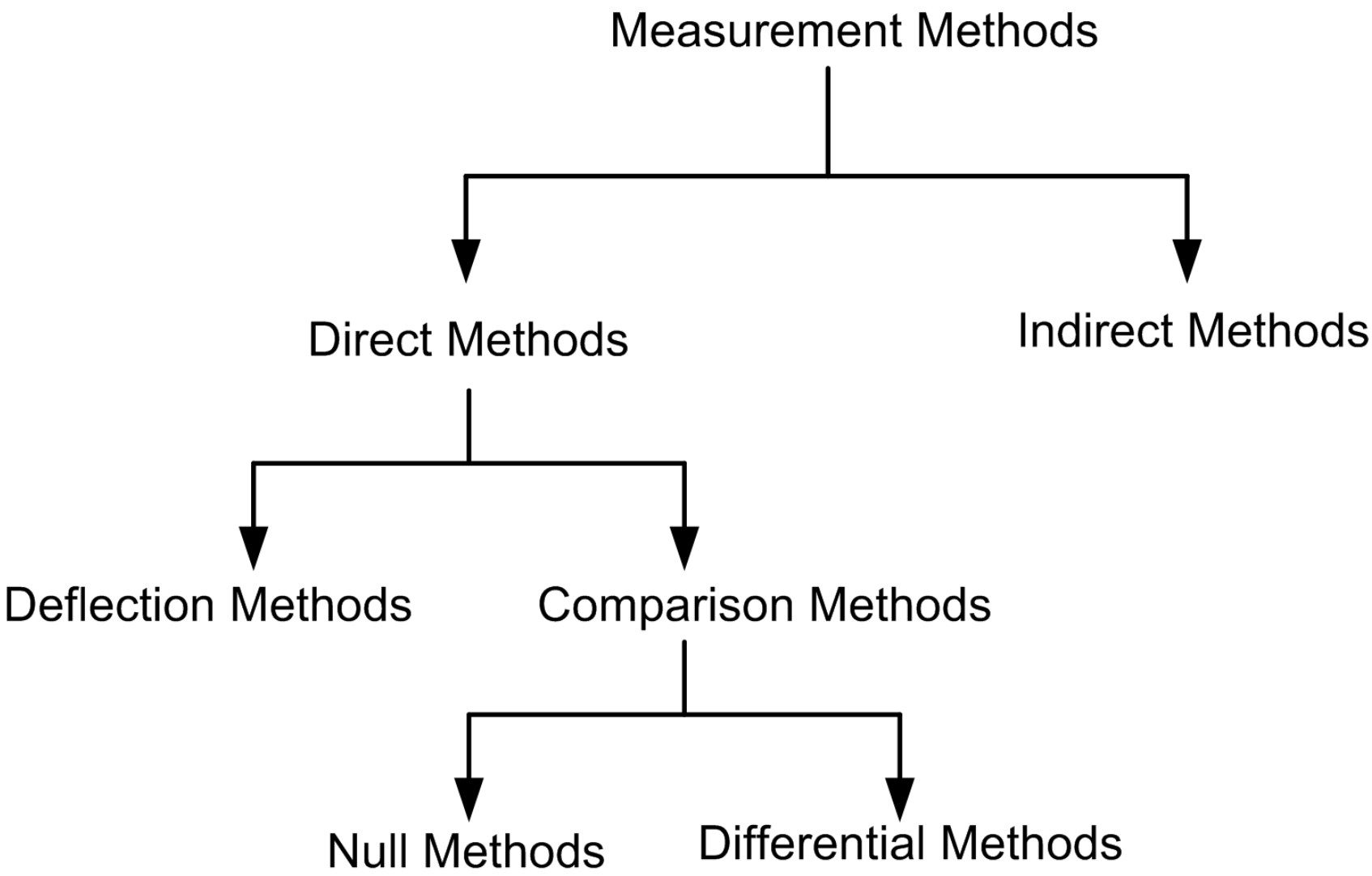
Significance of Measurements

- The measurement confirms the validity of a hypothesis and also add to its understanding.
- This eventually leads to new discoveries that require new and sophisticated measuring techniques.
- Through measurement a product can be designed or a process be operated with maximum efficiency, minimum cost, and with desired degree of reliability and maintainability.

Measured and True Values

- **Measured Value:**
  Any value or any reading calculated from measurement system or measuring instrument.
- **True Value:**
  Any value calculated from rated value known as true value of actual value. e.g. motor actual speed.
- **Error:**
  Any deviation of a measured value from a true value.
  "Error = measured value-true value".

Measurement Methods



Indirect Methods

- **Definition:**
  The comparison is done with a standard through the use of a calibrated system. These methods for measurement are used in those cases where the desired parameter to be measured is difficult to be measured directly, but the parameter has got some relation with some other related parameter which can be easily measured.
- **Example:**
  (a) Measuring the electric field inside a capacitor by measuring the voltage drop across its terminals ($E = V/D$ for parallel plate capacitor, where D is the distance between the two plates).
  (b) The elimination of bacteria from some fluid is directly dependent upon its temperature. Thus, the bacteria elimination can be measured indirectly by measuring the temperature of the fluid.

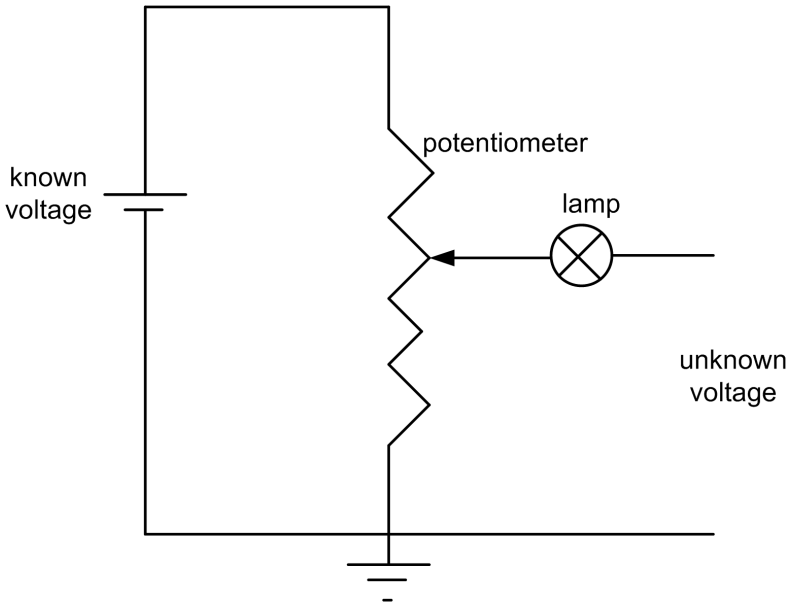
Direct Methods

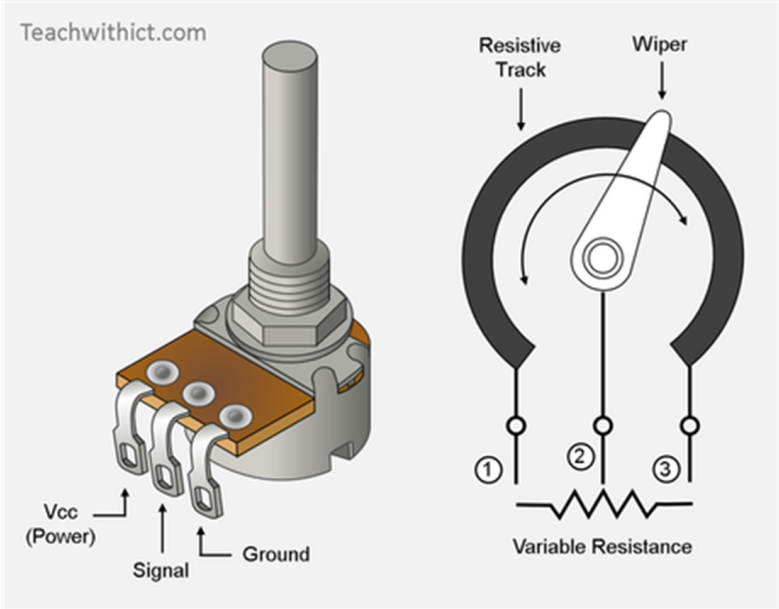
- The unknown quantity is measured directly.
- Direct methods of measurement are of two types, namely, *deflection methods and comparison methods*.

- *Deflection:*
  The value of the unknown quantity is measured by the help of a measuring instrument having a calibrated scale indicating the quantity under measurement directly, such as measurement of current by an ammeter (analog - Galvanometer type).
- *Comparison:*
  The value of the unknown quantity is determined by direct comparison with a standard of the given quantity, such as measurement of emf by comparison with the emf of a standard cell. Comparison methods can be classified as null methods and differential methods.

Direct-Comparison Methods (*Null Method*)

- The action of the unknown quantity upon the instrument is reduced to zero by the counter action of a known quantity of the same kind,
- **Examples:** measurement of weight by a balance, measurement of resistance, capacitance, and inductance by bridge circuits, and measurements of voltage by an potentiometer.





Direct-Comparison Methods (*Differential Method*)

- It is of great importance in checking measuring devices, which is the comparison with a standard of the measure being checked.
- If the difference between the quantity being measured and the known quantity is small, the measurement error will depend mainly on the accuracy to which the known quantity has been determined.

Definitions of Some Static Characteristics 1

- **Accuracy:**
  Is the closeness with which the instrument reading approaches the true value of the variable under measurement. Accuracy is determined as the maximum amount by which the result differs from the true (standard) value.
- Accuracy of the measured signal depends upon the following factors:
  - Intrinsic accuracy of the instrument itself;
  - Accuracy of the observer;
  - Variation of the signal to be measured;
  - Whether or not the quantity is being truly impressed upon the instrument.

Definitions of Some Static Characteristics 2

- **Precision:**
  Is a measure of the reproducibility of the measurements, i.e., precision is a measure of the degree to which successive measurements differ from one another. Precision is indicated from the number of significant figures in which it is expressed.

Definitions of Some Static Characteristics 3

- **Resolution:**
  Resolution or discrimination of any instrument is the smallest change in the input signal (quantity under measurement) which can be detected by the instrument.
- It is expressed as an accrual (absolute) value or as a fraction or percentage of the full scale value.
- Resolution is sometimes referred as sensitivity.

Definitions of Some Static Characteristics 4

- **Speed of Response:**
  The quickness of an instrument to read the measurand variable is called the speed of response.
- Alternately, speed of response is defined as the time elapsed between the start of the measurement to the reading taken. This time depends upon the mechanical moving system, friction, etc.

Measurement of errors

- The difference between the true or exact value and the measured value of the unknown quantity is known as the absolute error of the measurement.
- If ϵ_0 is the absolute error of the measurement, A_m and A are the measured and absolute value of the unknown quantity then δA is expressed as:

$$\epsilon_0 = A_m - A \tag{1}$$

- The relative error ϵ_r is the ratio of absolute error to the true value:

$$\epsilon_r = \frac{\epsilon_0}{A} \tag{2}$$

- If ϵ_0 is very small (negligible), i.e., $A \approx A_m$ then:

$$\epsilon_r = \frac{\epsilon_0}{A_m} \tag{3}$$