وزارة التخطيط

الجهاز المركزي للتقييس والسيطرة النوعية

دائرة التقييس / قسم المقاييس

# دراسة عامة في مجال القياسات الكهربائية

# General study in the field of electrical measurements

**دراسة مقدمة من**

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<u>**إطار الدراسة**</u>

**نود أن نشير إلى أن هذه الدراسة "دراسة عامة في مجال القياسات الكهربائية" تم تقديمها ضمن الخطة السنوية لقسم المقاييس لعام 2021 .**

**الحدود الزمانية: أعدت الدراسة من 2021/2/1 إلى 2021/11/10 .**

**الحدود المكانية: تم إعداد هذه الدراسة النظرية في دائرة التقييس / قسم المقاييس / □عبة القياسات الكهربائية والإلكترونية .**

## <u>Study framework</u>

**We would like to point out that this study "a general study in the field of electrical measurements" was presented within the annual plan of the Metrology Department for the year 2021.**

**Time limits: The study was prepared from 1/2/2021 to 10/11/2021 .**

**Spatial limits: This theoretical study was prepared in the standardization Department / Metrology Department / Electrical and Electronic Measurements Division .**

## Purpose

The study aims to clarify the concept of electrical measurements in metrology and what are the most important arithmetic parameters that must be available to the examiner in order to obtain accurate values and results that enable him to evaluate the device under examination.


## الخلاصة

تعنى هذه الدراسة بتوضيح مفاهيم لعناصر مهمة في علم القياس ( المترولوجيا ) , حيث تناولت شروحات عن علم القياس وما يحتويه من مصطلحات علمية مهمة تفيد الباحث في هذا المجال مركزة على مفهوم اللانأكدية في نتائج القياس والعلاقات الرياضية المعنية بحساباتها , كما وتستعرض تصنيفا علميا لأجهزة القياسات الكهربائية المستخدمة في هذا المجال .



## Abstract

This study is concerned with clarifying concepts of important elements in metrology, as it deals with explanations about metrology and the important scientific terms it contains that benefit the researcher in this field, focusing on the concept of uncertainty in measurement results and the mathematical relations concerned with their calculations, as well as reviews of electrical measurement devices scientifically classified used in this field.

## Introduction of Measurement

**Recently the measuring techniques changed significantly. Due to the development of informatics, microelectronics and mechatronics we can observe the real revolution in measurements.**

**Generally measuring devices are substituted by more flexible and universal computer measuring systems.**

**The wide spread of computer systems stimulated the development of sensor technology, interface systems, signal processing techniques, digital signal processors, measuring software(virtual instruments) and intelligent data analysis methods.**

**In common applications only several devices remained as "measuring devices", the examples being: digital multi meter, digital oscilloscope and digital counter analyzer, ect.**

## Symbols

**N.V : Nominal value**

**M.V : Measured value**

**A.V : Actual value**

**$U_c$ : combined uncertainty**

**$U_A$ : type A of uncertainty**

**$U_B$ : type B of uncertainty**

**$U_{exp}$ : Expanded uncertainty**

**K : coverage factor(K=2 for 95% of confidence level)**

**∑ : summation**

**б : Error value**

## Metrology

Metrology is defined as the science and art of measurement, which includes all theoretical and practical topics related to measurements, regardless of their accuracy or the levels of uncertainty associated with them.[1]

Metrology it contains three important terms,

1. Estimation.

2. Standard unit.

3. Uncertainty of estimation.

Without the knowledge of the uncertainty of estimation the whole measurement process is worthless.

Therefore, in this research we will assume simplified definition of the measurement.

(the measurement is the estimation of the quantity of certain

value (with known uncertainty) by comparison with the standard unit.)

from this simplified definition confirm the important aspect of the measurement process .

The logical sequence of operations used in measurements is called as the method of measurement. To perform a measurement we should have established a measuring procedure as the detailed description of measurement according to the measuring principles and to given method of measurement.

The measuring procedure is used in the definition of a measurement unit, in obtaining the quantity value and measured uncertainty .

## Definitions[1]

Some definitions of terms used in the measurement process :

**Measurement :**

A set of operations aimed at setting the value of a certain quantity, such as measuring time, temperature...etc. It may be performed automatically, manually, or both.

**Measured quantity:**

The quantity under measurement and whose exact amount is to be known, as the value of an unknown resistance.

**True value :**

The value determined according to the international definition of quantity. This value can only be obtained with perfect measurements that are completely free of errors.

**Nominal value :**

It is the usual nominal value of the quantity to be measured, such as the value written on the resistance for example.

**Measured value** :

**It is the amount of the nominal value after it has been measured by an appropriate of measurement.**

**Actual value** :

**It is the value measured by an accurate measuring device plus the correction value required for the measuring device.**

**A.V = M.V + correction**

**Error** :

**It is the difference between the Nominal value and its Actual value.**

**ERROR = N.V – A.V**

## Uncertainty

**measurement uncertainty is the expression of the statistical dispersion of the values attributed to a measured quantity.[1]**

**All measurements are subject to uncertainty and a measurement result is complete only when it is accompanied by a statement of the associated uncertainty, such as the standard deviation. By international agreement, this uncertainty has a probabilistic basis and reflects incomplete knowledge of the quantity value. It is a non-negative parameter.**

**The measurement uncertainty is often taken as the standard deviation of a state-of-knowledge probability distribution over the possible values that could be attributed to a measured quantity.**

**Relative uncertainty is the measurement uncertainty relative to the magnitude of a particular single choice for the value for the measured quantity, when this choice is nonzero. This particular single choice is usually called the measured value, which may be optimal in some well-defined sense (e.g., a mean, median, or mode). Thus, the relative measurement uncertainty is the measurement uncertainty divided by**

**the absolute value of the measured value, when the measured value is not zero.**

**No measurement is exact. When a quantity is measured, the outcome depends on the measuring system, the measurement procedure, the skill of the operator, the environment, and other effects. Even if the quantity were to be measured several times, in the same way and in the same circumstances, a different measured value would in general be obtained each time, assuming the measuring system has sufficient resolution to distinguish between the values.**

**The dispersion of the measured values would relate to how well the measurement is performed. Their average would provide an estimate of the true value of the quantity that generally would be more reliable than an individual measured value. The dispersion and the number of measured values would provide information relating to the average value as an estimate of the true value. However, this information would not generally be adequate.**

**Knowledge about an input quantity is inferred from repeated measured values (Type A evaluation of uncertainty), or scientific judgment or other information concerning the possible values of the quantity (Type B evaluation of uncertainty).**

**In Type A evaluations of measurement uncertainty, the assumption is often made that the distribution best describing an input quantity given repeated measured values of it (obtained independently) . then**

**has expectation equal to the average measured value and standard deviation equal to the standard deviation of the average. When the uncertainty is evaluated from a small number of measured values, the corresponding distribution can be taken as a distribution. Other considerations apply when the measured values are not obtained independently.**

**$U_a = б/\sqrt{n}$[2][3]**

**For a Type B evaluation of uncertainty, often the only available information is that lies in a specified interval. In such a case, knowledge of the quantity can be characterized by a rectangular probability distribution. If different information were available, a probability distribution consistent with that information would be used.**

**$U_B = \sum(B1, B2, B3, \ldots\ldots)$[2]**

**Then the Expanded uncertainty will calculate from the relation:**

**$U_{exp} = KU_C$[2][3]**

**$= K \sqrt{(U_A^2 + U_B^2)}$[2][3]**

## Classification of Electrical Measuring Instrument

### 3.1. according to the Electrical Quantity

**As per the Electrical Quantities, instruments are broadly classified into two parts:**

- **Absolute Instrument**
- **Secondary Instrument**

### 3.1.1. Absolute Instrument

**This instrument gives the value of the electrical quantity to measure in terms of the constant and its deflection.**

**It is also called a** Primary Instrument **or** Indirect Instrument*.* **These**

**instruments are not required to compare with the standard values.**

Example: **Tangent Galvanometer.**

### 3.1.2. Secondary Instrument

**The instrument gives the value of the quantity to be measured directly into the deflection. This instrument is known as** Direct Instruments**.**

**These instrument values are required to compare with absolute instruments or standard value of the instruments.**

**The secondary instrument is classified into two parts:**

- **Deflection Instrument**
- **Null Deflection Instrument**

Example: **Ammeter, Voltmeter, Wattmeter, … etc**

## 3.2. <u>According to the Electrical Supply</u>

**This classification is based on the types of an electrical source.**

- **AC Instrument**
- **DC Instrument**

## 3.3. <u>According to an Electrical Application</u>

**In daily routine, multiple instruments are used for multiple purposes. Instruments work on AC or DC electrical source as per the appliances use.**

**Here is the list of the most popular and widely used instruments.**

a. **Ammeter**
b. **Voltmeter**
c. **Ohmmeter**
d. **Multimeter**
e. **Watt meter**
f. **LCR meter**
g. **Oscilloscope**
h. **Galvanometer**
i. **Energy meter**
j. **Frequency meter**
k. **Earth leakage detector**
l. **Insulation fault detecting instrument**
m. **Megger, etc.**

**These instruments are used in commercial, industrial, practically and many more purposes.**

## <u>Example</u> :

**If we take the multi meter as example of multi functions instrument**

 

**we see that there are two type of it :**

- **Analog type multi meter**
- **Digital type multi meter**

**The difference between them is :**

**The analog type of multi meter shows the continuous signal. It detects and displays the electrical reading by using the moving pointer.**

**While , digital type of multi meter shows the discrete signal. And it measures and displays the numeric measuring unit or value.**

**So, digital multi meter (DMM) gives a more accurate, fast response and readable digital output over analog multi meter.**

**We used this device to measure current, voltage, resistance .**
**Similarly, there is the LCR meter it is a type of multi meter which measures the inductance (L), capacitance (C), resistance (R).**

**electrical measurement is a comparison between actual measurement value and standard value. This value is also called as 'True value'.**
**After comparing, there can be some deviation called 'Error'. The error is the deviation of the measurement value to the standard value. It is denoted by 'б'.**
**Mathematically represent as,**

**Error (б)= [(Measured value)-(Standard value)]**

**The standard value can be represented by the quantity unit with defined uncertainty.**

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