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INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

High-voltage test techniques –
Part 2: Measuring systems

Techniques des essais à haute tension –
Partie 2: Systèmes de mesure

IEC 60060-2:2010

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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FOREWORD

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International Standard IEC 60060-2 has been prepared by IEC technical committee 42: High-voltage test techniques.

This third edition of IEC 60060-2 cancels and replaces the second edition, published in 1994, and constitutes a technical revision.

The significant technical changes with respect to the previous edition are as follows:

a) The general layout and text was updated and improved to make the standard easier to use.
b) The standard was revised to align it with IEC 60060-1.
c) The treatment of measurement uncertainty estimation has been expanded.

The text of this standard is based on the following documents:

FDIS	Report on voting
42/281/FDIS	42/287/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

A list of all parts of IEC 60060 series, under the general title *High-voltage test techniques*, can be found on the IEC website.

This publication has been drafted in accordance with the ISO/IEC Directives, Part-2.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to this specific publication. At this date, the publication will be:

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

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HIGH-VOLTAGE TEST TECHNIQUES –

Part 2: Measuring systems

1 Scope

This part of IEC 60060 is applicable to complete measuring systems, and to their components, used for the measurement of high voltages during laboratory and factory tests with direct voltage, alternating voltage and lightning and switching impulse voltages as specified in IEC 60060-1. For measurements during on-site tests see IEC 60060-3.

The limits on uncertainties of measurements stated in this standard apply to test levels stated in IEC 60071-1:2006. The principles of this standard apply also to higher levels but the uncertainty may be greater.

This standard:

- defines the terms used;
- describes methods to estimate the uncertainties of high-voltage measurements;
- states the requirements which the measuring systems shall meet;
- describes the methods for approving a measuring system and checking its components;
- describes the procedures by which the user shall show that a measuring system meets the requirements of this standard, including the limits set for the uncertainty of measurement.

2 Normative references

The following referenced documents are indispensable for the application of this standard. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60052, *Voltage measurement by means of standard air gaps*

IEC 60060-1, *High-voltage test techniques – Part 1: General definitions and test requirements*

IEC 61083-1, *Instruments and software used for measurement in high-voltage impulse tests – Part 1: Requirements for instruments*

IEC 61083-2, *Digital recorders for measurement in high-voltage impulse tests – Part 2: Evaluation of software used for the determination of the parameters of impulse waveforms*

ISO/IEC Guide 98-3:2008, *Uncertainty of measurement – Part 3: Guide to the expression of uncertainty in measurements (GUM)*

NOTE Further related standards, guides, etc. on subjects included in this International Standard are given in the bibliography.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1 Measuring systems

3.1.1
measuring system
complete set of devices suitable for performing a high-voltage measurement; software, used to obtain or calculate measuring results, also forms a part of the measuring system

NOTE 1 A measuring system usually comprises the following components:

– a converting device with the leads required for connecting this device to the test object or into the circuit and the connections to earth;

– a transmission system connecting the output terminals of the converting device to the measuring instruments with its attenuating, terminating and adapting impedances or networks;

– a measuring instrument together with any connection to the power supply. Measuring systems which comprise only some of the above components or which are based on non-conventional principles are acceptable if they meet the uncertainty requirements specified in this document.

NOTE 2 The environment in which a measuring system functions, its clearances to live and earthed structures and the presence of electric or magnetic fields may significantly affect the measurement result and its uncertainty.

3.1.2
record of performance
detailed record, established and maintained by the user, describing the measuring system and containing evidence that the requirements given in this standard have been met

NOTE This evidence includes the results of the initial performance test and the schedule and results of each subsequent performance test and performance check.

3.1.3
approved measuring system
measuring system that is shown to comply with one or more of the sets of requirements set out in this document

3.1.4
reference measuring system
measuring system with its calibration traceable to relevant national and/or international standards, and having sufficient accuracy and stability for use in the approval of other systems by making simultaneous comparative measurements with specific types of waveform and ranges of voltage

NOTE A reference measuring system (maintained according to the requirements of this standard) may be used as an approved measuring system but the converse is not true.

3.2 Components of a measuring system

3.2.1
converting device
device for converting the quantity to be measured (measurand) into a quantity, compatible with the measuring instrument

3.2.2
voltage divider
converting device consisting of a high-voltage and a low-voltage arm such that the input voltage is applied across the complete device and the output voltage is taken from the low-voltage arm

NOTE The elements of the two arms are usually resistors or capacitors or combinations of these. The device is designated by the type and arrangement of its elements (for example, resistive, capacitive or resistive-capacitive).

3.2.3
voltage transformer
converting device consisting of a transformer in which the secondary voltage, in normal conditions of use, is substantially proportional to the primary voltage and differs in phase from it by an angle which is approximately zero for an appropriate direction of the connections

[IEC 60050-321: 1986, 321-03-01]

3.2.4
voltage converting impedance
converting device which carries a current proportional to the applied voltage to be measured with a current measuring instrument

3.2.5
electric-field probe
converting device for the measurement of the amplitude and waveform of an electric field

NOTE An electric-field probe may be used to measure the waveform of the voltage producing the field provided that the measurement is not affected by corona or space charges.

3.2.6
transmission system
set of devices that transfers the output signal of a converting device to a measuring instrument

NOTE 1 A transmission system usually consists of a coaxial cable with its terminating impedance, but it may include attenuators, amplifiers, or other devices connected between the converting device and the measuring instrument. For example, an optical link includes a transmitter, an optical cable and a receiver as well as related amplifiers.

NOTE 2 A transmission system may be partially or completely included in the converting device or in the measuring instrument.

3.2.7
measuring instrument
device intended to make measurements, alone or in conjunction with supplementary devices

[IEC 60050-300: 2001, 311-03-01]

3.3 Scale factors

3.3.1
scale factor of a measuring system
factor by which the value of the measuring-instrument reading is multiplied to obtain the value of the input quantity of the complete measuring system

NOTE 1 A measuring system may have multiple scale factors for different assigned measurement ranges, frequency ranges or waveforms.

NOTE 2 For measuring systems that display the value of the input quantity directly, the nominal scale factor of the measuring system is unity.

3.3.2
scale factor of a converting device
factor by which the output of the converting device is multiplied to obtain its input quantity

NOTE The scale factor of a converting device may be dimensionless (for example, the ratio of a divider) or may have dimensions (for example, the impedance of a voltage converting impedance).

3.3.3
scale factor of a transmission system
factor by which the output of a transmission system is multiplied to obtain its input quantity

3.3.4
scale factor of a measuring instrument
factor by which the instrument reading is multiplied to obtain its input quantity

3.3.5
assigned scale factor
F
scale factor of a measuring system determined at the most recent performance test

NOTE A measuring system may have more than one assigned scale factor; for example, it may have several ranges and/or nominal epochs, each with a different scale factor.

3.4 Rated values

3.4.1
operating conditions
specified ranges of conditions under which a measuring system will operate within the specified uncertainty limits

3.4.2
rated operating voltage
maximum level of voltage of specified frequency or waveform at which a measuring system is designed to be used

NOTE The rated operating voltage may be higher than the upper limit of the assigned measurement range.

3.4.3
assigned measurement range
range of voltage of specified frequency or waveform, characterized by a single scale factor, in which a measuring system may be used

NOTE 1 The limits of the assigned measurement range are chosen by the user and verified by the performance tests specified in this standard.

NOTE 2 A measuring system can have more than one assigned measurement range with different scale factors.

3.4.4
assigned operating time
longest time during which a measuring system for direct or alternating voltages can operate at the upper limit of the assigned measurement range

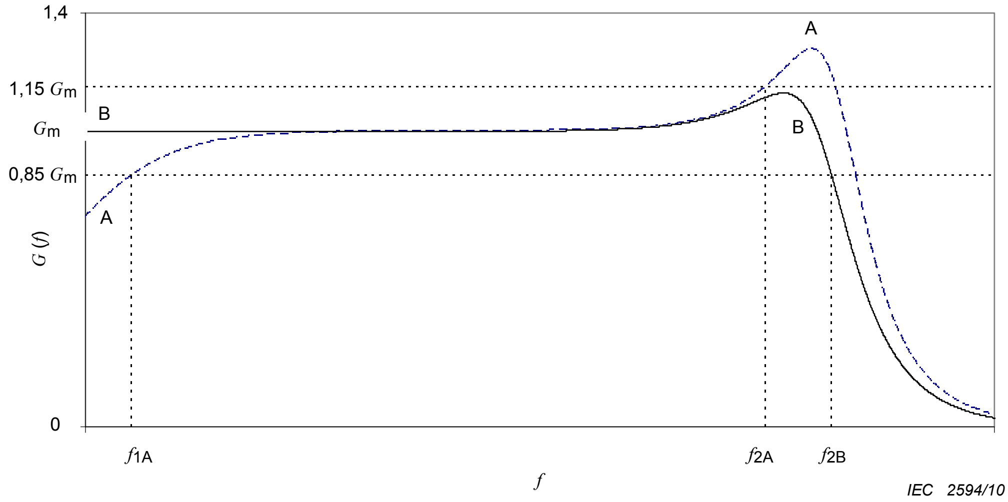
3.4.5
assigned rate of application
highest rate of specified voltage impulses for a specified time interval, at which the measuring system can operate at its upper limit of the assigned measurement range

NOTE The rate is usually given as applications per minute and the time interval in minutes or hours.

3.5 Definitions related to dynamic behaviour

3.5.1
response of a measuring system,
G
output, as a function of time or frequency, when a specified voltage is applied to the input of the system

3.5.2
amplitude-frequency response,
G(f)
ratio of the output to the input of a measuring system as a function of frequency f, when the input is sinusoidal (see Figure 1)



NOTE Lower and upper limit frequencies are shown on curve A.

Curve B shows a constant response down to direct voltage.

Figure 1 – Amplitude-frequency response with examples for limit frequencies (f_1; f_2)

3.5.3
step response,
G(t)
output of a measuring system as a function of time when the input is a step function

NOTE For more information on step response and step-response parameters see Annex C.

3.5.4
nominal epoch (impulse voltage only),
τ_{N1}
range of values between the minimum (t_{min}) and the maximum (t_{max}) of the relevant time parameter of impulse voltage for which the measuring system is to be approved

NOTE 1 The relevant time parameter is:

– the front time T_1 for full and tail-chopped lightning impulses

– the time to chopping T_c for front-chopped impulses

– the time to peak T_p for switching impulses

NOTE 2 A measuring system may have one, two or more nominal epochs for different waveforms. For example, a particular measuring system might be approved:

– for full and tail-chopped lightning impulses with an assigned scale factor F_1 over a nominal epoch τ_{N1} from T_1 = 0,8 µs to T_1 = 1,8 µs, even though the tolerance is 0,84 µs to 1,56 µs;

– or front-chopped lightning impulses with an assigned scale factor F_2 over a nominal epoch τ_{N2} from T_c = 0,5 µs to T_c = 0,9 µs;

– for switching impulses with an assigned scale factor F_3 over a nominal epoch τ_{N3} from T_p = 150 µs to T_p = 500 µs.

NOTE 3 "Front-chopped impulse" is used to designate a chopped impulse with a time to chopping that falls in the range 0,5 µs to the time of the extreme value. This is to be distinguished from a "tail-chopped impulse" which has a time to chopping greater than the time of the extreme value.

3.5.5
limit frequencies,
f_1 and f_2
lower and upper limits of the range within which the amplitude-frequency response is nearly constant (Figure1)

NOTE These limits are where the response first deviates by a certain amount (e.g. plus/minus 15 %) from the constant value. The permissible deviation should be related to acceptable uncertainties of a measuring system.

3.6 Definitions related to uncertainty

3.6.1
tolerance
permitted difference between the measured value and the specified value

NOTE 1 This difference should be distinguished from the uncertainty of measurement.

NOTE 2 The measured test voltage is required to lie within the stated tolerance of the specified test level.

3.6.2
error
measured quantity value minus a reference quantity value

[ISO/IEC Guide 99 (VIM 2.16)]

3.6.3
uncertainty (of measurement)

parameter, associated with the result of a measurement, that characterises the dispersion of the values that could reasonably be attributed to the measurand

[IEC 60050-300: 2001, 311-01-02]

NOTE 1 Uncertainty is positive and given without sign.

NOTE 2 Uncertainty of voltage measurement should not be confused with the tolerance of a specified test voltage.

NOTE 3 For more information see Annexes A and B.

3.6.4
standard uncertainty,
u
uncertainty of the result of a measurement expressed as a standard deviation

[ISO/IEC Guide 98-3 (GUM 2.3.1)]

NOTE 1 The standard uncertainty associated with an estimate of a measurand has the same dimension as the measurand.

NOTE 2 In some cases, the relative standard uncertainty of a measurement may be appropriate. The relative standard uncertainty of measurement is the standard uncertainty divided by the measurand, and is therefore dimensionless.

3.6.5
combined standard uncertainty,
u_c,
standard uncertainty of the result of a measurement when that result is obtained from the values of a number of other quantities, equal to the positive square root of a sum of terms, the terms being the variances or covariances of these other quantities weighted according to how the measurement result varies with changes in these quantities

[ISO/IEC Guide 98-3 (GUM 2.3.4)]