



NSAI
Standards

Irish Standard
I.S. EN 60060-2:2011

High-voltage test techniques -- Part 2: Measuring systems (IEC 60060-2:2010 (EQV))

I.S. EN 60060-2:2011

Incorporating amendments/corrigenda issued since publication:

The National Standards Authority of Ireland (NSAI) produces the following categories of formal documents:

I.S. xxx: Irish Standard – national specification based on the consensus of an expert panel and subject to public consultation.

S.R. xxx: Standard Recommendation - recommendation based on the consensus of an expert panel and subject to public consultation.

SWiFT xxx: A rapidly developed recommendatory document based on the consensus of the participants of an NSAI workshop.

<i>This document replaces:</i> EN 60060-2:1994+A11:1998	<i>This document is based on:</i> EN 60060-2:2011	<i>Published:</i> 28 January, 2011
This document was published under the authority of the NSAI and comes into effect on: 14 February, 2011		ICS number: 17.220.20 19.080
NSAI 1 Swift Square, Northwood, Santry Dublin 9	T +353 1 807 3800 F +353 1 807 3838 E standards@nsai.ie W NSAI.ie	Sales: T +353 1 857 6730 F +353 1 857 6729 W standards.ie
Údarás um Chaighdeáin Náisiúnta na hÉireann		

I.S. EN 60060-2:2011

EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

EN 60060-2

January 2011

ICS 17.220.20; 19.080

Supersedes EN 60060-2:1994 + A11:1998

English version

**High-voltage test techniques -
Part 2: Measuring systems
(IEC 60060-2:2010)**

Techniques des essais à haute tension -
Partie 2: Systèmes de mesure
(CEI 60060-2:2010)

Hochspannungs-Prüftechnik -
Teil 2: Messsysteme
(IEC 60060-2:2010)

This European Standard was approved by CENELEC on 2011-01-01. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the Central Secretariat has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Bulgaria, Croatia, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

Management Centre: Avenue Marnix 17, B - 1000 Brussels

Foreword

The text of document 42/281/FDIS, future edition 3 of IEC 60060-2, prepared by IEC TC 42, High-voltage testing techniques, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 60060-2 on 2011-01-01.

This European Standard supersedes EN 60060-2:1994 + A11:1998.

The significant technical changes with respect to EN 60060-2:1994+A11:1998 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 EN 60060-1.
- c) The treatment of measurement uncertainty estimation has been expanded.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN and CENELEC shall not be held responsible for identifying any or all such patent rights.

The following dates were fixed:

- | | | |
|--|-------|------------|
| – latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement | (dop) | 2011-10-01 |
| – latest date by which the national standards conflicting with the EN have to be withdrawn | (dow) | 2014-01-01 |

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 60060-2:2010 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standards indicated:

IEC 60051 series	NOTE	Harmonized in EN 60051 series (not modified).
IEC 60060-3:2006	NOTE	Harmonized as EN 60060-3:2006 (not modified).
IEC 60071-1:2006	NOTE	Harmonized as EN 60071-1:2006 (not modified).
IEC 60270	NOTE	Harmonized as EN 60270.
IEC 62475	NOTE	Harmonized as EN 62475.
ISO/IEC 17025:2005	NOTE	Harmonized as EN ISO/IEC 17025:2005 (not modified).

Annex ZA (normative)

Normative references to international publications with their corresponding European publications

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

NOTE When an international publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC 60052	-	Voltage measurement by means of standard air gaps	EN 60052	-
IEC 60060-1	-	High-voltage test techniques - Part 1: General definitions and test requirements	EN 60060-1	-
IEC 61083-1	-	Instruments and software used for measurement in high-voltage impulse tests - Part 1: Requirements for instruments	EN 61083-1	-
IEC 61083-2	-	Digital recorders for measurements in high-voltage impulse tests - Part 2: Evaluation of software used for the determination of the parameters of impulse waveforms	EN 61083-2	-
ISO/IEC Guide 98-3 2008		Uncertainty of measurement - Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)	-	-

This page is intentionally left BLANK.

CONTENTS

FOREWORD.....	6
1 Scope.....	8
2 Normative references.....	8
3 Terms and definitions.....	8
3.1 Measuring systems	9
3.2 Components of a measuring system.....	9
3.3 Scale factors	10
3.4 Rated values	11
3.5 Definitions related to dynamic behaviour	11
3.6 Definitions related to uncertainty.....	13
3.7 Definitions related to tests on measuring systems	14
4 Procedures for qualification and use of measuring systems.....	15
4.1 General principles.....	15
4.2 Schedule of performance tests	16
4.3 Schedule of performance checks	16
4.4 Requirements for the record of performance	16
4.4.1 Contents of the record of performance	16
4.4.2 Exceptions	17
4.5 Operating conditions	17
4.6 Uncertainty.....	17
5 Tests and test requirements for an approved measuring system and its components	18
5.1 General requirements.....	18
5.2 Calibration – Determination of the scale factor	19
5.2.1 Calibration of measuring systems by comparison with a reference measuring system (preferred method)	19
5.2.2 Determination of the scale factor of a measuring system from the scale factors of its components (alternative method).....	22
5.3 Linearity test.....	23
5.3.1 Application	23
5.3.2 Alternative methods in order of suitability	24
5.4 Dynamic behaviour.....	25
5.4.1 General.....	25
5.4.2 Determination of the amplitude/frequency response.....	25
5.4.3 Reference method for impulse voltage measuring systems	26
5.5 Short-term stability.....	26
5.6 Long-term stability.....	26
5.7 Ambient temperature effect	27
5.8 Proximity effect.....	27
5.9 Software effect	27
5.10 Uncertainty calculation of the scale factor.....	27
5.10.1 General.....	27
5.10.2 Uncertainty of the calibration.....	28
5.10.3 Uncertainty of measurement using an approved measuring system	29
5.11 Uncertainty calculation of time parameter measurement (impulse voltages only).....	30
5.11.1 General.....	30

5.11.2	Uncertainty of the time parameter calibration	30
5.11.3	Uncertainty of time parameter measurement using an approved measuring system	31
5.12	Interference test (transmission system and instrument for impulse voltage measurements)	32
5.13	Withstand tests of converting device	32
6	Measurement of direct voltage	33
6.1	Requirements for an approved measuring system	33
6.1.1	General	33
6.1.2	Uncertainty contributions	33
6.1.3	Requirement on converting device	33
6.1.4	Dynamic behaviour for measuring voltage changes	33
6.2	Tests on an approved measuring system	33
6.3	Performance check	34
6.3.1	General	34
6.3.2	Comparison with an approved measuring system	34
6.3.3	Check of the scale factors of the components	35
6.4	Measurement of ripple amplitude	35
6.4.1	Requirements	35
6.4.2	Uncertainty contributions	35
6.4.3	Calibrations and tests on an approved ripple voltage measuring system	35
6.4.4	Measurement of the scale factor at the ripple frequency	35
6.4.5	Dynamic behaviour by amplitude/frequency response	35
6.4.6	Performance check for ripple measuring system	36
7	Measurement of alternating voltage	36
7.1	Requirements for an approved measuring system	36
7.1.1	General	36
7.1.2	Uncertainty contributions	36
7.1.3	Dynamic behaviour	36
7.2	Tests on an approved measuring system	38
7.3	Dynamic behaviour test	38
7.4	Performance check	38
7.4.1	General	38
7.4.2	Comparison with an approved measuring system	38
7.4.3	Check of the scale factors of the components	39
8	Measurement of lightning impulse voltage	40
8.1	Requirements for an approved measuring system	40
8.1.1	General	40
8.1.2	Uncertainty contributions	40
8.1.3	Requirement on measuring instrument	40
8.1.4	Dynamic behaviour	40
8.1.5	Connection to the test object	40
8.2	Tests on an approved measuring system	41
8.3	Performance test on measuring systems	42
8.3.1	Reference method (preferred)	42
8.3.2	Alternative method supplemented by a measurement of the step response according to Annex C	42
8.4	Dynamic behaviour test	43

8.4.1	Comparison with a reference measuring system (preferred).....	43
8.4.2	Alternative method based on step response parameters (Annex C)	43
8.5	Performance check	43
8.5.1	Comparison with an approved measuring system	43
8.5.2	Check of the scale factors of the components	43
8.5.3	Dynamic behaviour check by reference record	43
9	Measurement of switching impulse voltage.....	43
9.1	Requirements for an approved measuring system.....	43
9.1.1	General.....	43
9.1.2	Uncertainty contribution.....	44
9.1.3	Requirements for the measuring instrument	44
9.1.4	Dynamic behaviour.....	44
9.1.5	Connection to the test object.....	44
9.2	Tests on an approved measuring system	44
9.3	Performance test on measuring systems	44
9.3.1	Reference method (preferred)	44
9.3.2	Alternative methods supplemented by a step response measurement.....	45
9.4	Dynamic behaviour test by comparison.....	45
9.5	Performance check	45
9.5.1	Scale factor check by comparison with an approved measuring system	45
9.5.2	Check of the scale factors of the components	45
9.5.3	Dynamic behaviour check by reference record	45
10	Reference measuring systems	47
10.1	Requirements for reference measuring systems	47
10.1.1	Direct voltage	47
10.1.2	Alternating voltage	47
10.1.3	Full and chopped lightning and switching impulse voltages.....	47
10.2	Calibration of a reference measuring system.....	47
10.2.1	General.....	47
10.2.2	Reference method: Comparative measurement	47
10.2.3	Alternative method for impulse voltages: Measurement of scale factor and evaluation of step response parameters	47
10.3	Interval between successive calibrations of reference measuring systems	47
10.4	Use of reference measuring systems.....	48
Annex A (informative)	Uncertainty of measurement	49
Annex B (informative)	Examples for the calculation of measuring uncertainties in high-voltage measurements	57
Annex C (informative)	Step response measurements	65
Annex D (informative)	Convolution method for the determination of dynamic behaviour from step response measurements.....	70
Bibliography	73
Figure 1	– Amplitude-frequency response with examples for limit frequencies (f_1 ; f_2).....	12
Figure 2	– Calibration by comparison over the full voltage range	20
Figure 3	– Uncertainty contributions of the calibration (example with minimum of 5 voltage levels).....	21
Figure 4	– Calibration by comparison over a limited voltage range, with an additional linearity test.....	22

Figure 5 – Linearity test of the measuring system with a linear device in the extended voltage range	24
Figure 6 – Shaded area for acceptable normalised amplitude-frequency responses of measuring systems intended for single fundamental frequencies f_{nom} (to be tested in the range $(1...7)f_{\text{nom}}$)	37
Figure 7 – Shaded area for acceptable normalised amplitude-frequency responses of measuring systems intended for a range of fundamental frequencies f_{nom1} to f_{nom2} (to be tested in the range f_{nom1} to $7 f_{\text{nom2}}$)	38
Figure A.1 – Normal probability distribution $p(x)$	55
Figure A.2 – Rectangular probability distribution $p(x)$	56
Figure B.1 – Comparison between the system under test, X, and the reference system, N ...	64
Figure B.2 – Front time deviation ΔT_{1j} of system X, related to the reference system N, and their mean ΔT_{1m} in the range of $T_1 = 0,8 \mu\text{s} \dots 1,6 \mu\text{s}$	64
Figure C.1 – Definitions of response parameters	68
Figure C.2 – A unit-step response $g(t)$ showing an initial distortion of initial distortion time T_0	69
Figure C.3 – Suitable circuits for step response measurement	69
Table 1 – Tests required for an approved direct voltage measuring system	34
Table 2 – Required tests for uncertainty contributions in ripple measurement	36
Table 3 – Tests required for an approved alternating voltage measuring system	39
Table 4 – Tests required for an approved lightning impulse voltage measuring system	41
Table 5 – Tests required for a switching impulse voltage measuring system	46
Table 6 – Recommended response parameters for impulse voltage reference measuring systems	48
Table A.1 – Coverage factor k for effective degrees of freedom ν_{eff} ($p = 95,45 \%$)	54
Table A.2 – Schematic of an uncertainty budget	55
Table B.1 – Result of the comparison measurement at a single voltage level	58
Table B.2 – Summary of results for $h = 5$ voltage levels ($V_{X\text{max}} = 500 \text{ kV}$)	59
Table B.3 – Uncertainty budget of the assigned scale factor F_X	60
Table B.4 – Uncertainty budget of the assigned scale factor F	61
Table B.5 – Calibration result for front time T_1 and deviations	63
Table B.6 – Uncertainty budget of the front time deviation $\Delta T_{1\text{cal}}$	63

INTERNATIONAL ELECTROTECHNICAL COMMISSION

HIGH-VOLTAGE TEST TECHNIQUES –

Part 2: Measuring systems

FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

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.

I.S. EN 60060-2:2011

60060-2 © IEC:2010

– 7 –

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.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

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.

This is a free preview. Purchase the entire publication at the link below:

[Product Page](#)

-
- Looking for additional Standards? Visit Intertek Inform Infostore
 - Learn about LexConnect, All Jurisdictions, Standards referenced in Australian legislation
-