

© Copyright SEK. Reproduction in any form without permission is prohibited.

## Beräkning av osäkerhet hos vågformsparametrar

*Computation of waveform parameter uncertainties*

Som svensk standard gäller europastandarden EN 62754:2017. Den svenska standarden innehåller den officiella engelska språkversionen av EN 62754:2017.

### Nationellt förord

Europastandarden EN 62754:2017

består av:

- **europastandardens ikraftsättningsdokument**, utarbetat inom CENELEC
- **IEC 62754, First edition, 2017 - Computation of waveform parameter uncertainties**

utarbetad inom International Electrotechnical Commission, IEC.

---

ICS 17.220.20

Denna standard är fastställd av SEK Svensk Elstandard,  
som också kan lämna upplysningar om **sakinnehållet** i standarden.  
Postadress: Box 1284, 164 29 KISTA  
Telefon: 08 - 444 14 00.  
E-post: sek@elstandard.se. Internet: [www.elstandard.se](http://www.elstandard.se)

---

## *Standarder underlättar utvecklingen och höjer elsäkerheten*

Det finns många fördelar med att ha gemensamma tekniska regler för bl a mätning, säkerhet och provning och för utförande, skötsel och dokumentation av elprodukter och elanläggningar.

Genom att utforma sådana standarder blir säkerhetsfordringar tydliga och utvecklingskostnaderna rimliga samtidigt som marknadens acceptans för produkten eller tjänsten ökar.

Många standarder inom elområdet beskriver tekniska lösningar och metoder som åstadkommer den elsäkerhet som föreskrivs av svenska myndigheter och av EU.

## *SEK är Sveriges röst i standardiseringsarbetet inom elområdet*

SEK Svensk Elstandard svarar för standardiseringen inom elområdet i Sverige och samordnar svensk medverkan i internationell och europeisk standardisering. SEK är en ideell organisation med frivilligt deltagande från svenska myndigheter, företag och organisationer som vill medverka till och påverka utformningen av tekniska regler inom elektrotekniken.

SEK samordnar svenska intressenters medverkan i SEKs tekniska kommittéer och stödjer svenska experters medverkan i internationella och europeiska projekt.

## *Stora delar av arbetet sker internationellt*

Utformningen av standarder sker i allt väsentligt i internationellt och europeiskt samarbete. SEK är svensk nationalkommitté av International Electrotechnical Commission (IEC) och Comité Européen de Normalisation Electrotechnique (CENELEC).

Standardiseringsarbetet inom SEK är organiserat i referensgrupper bestående av ett antal tekniska kommittéer som speglar hur arbetet inom IEC och CENELEC är organiserat.

Arbetet i de tekniska kommittéerna är öppet för alla svenska organisationer, företag, institutioner, myndigheter och statliga verk. Den årliga avgiften för deltagandet och intäkter från försäljning finansierar SEKs standardiseringsverksamhet och medlemsavgift till IEC och CENELEC.

## *Var med och påverka!*

Den som deltar i SEKs tekniska kommittéarbete har möjlighet att påverka framtida standarder och får tidig tillgång till information och dokumentation om utvecklingen inom sitt teknikområde. Arbetet och kontakterna med kollegor, kunder och konkurrenter kan gynnsamt påverka enskilda företags affärsutveckling och bidrar till deltagarnas egen kompetensutveckling.

Du som vill dra nytta av dessa möjligheter är välkommen att kontakta SEKs kansli för mer information.

## **SEK Svensk Elstandard**

Box 1284  
164 29 Kista  
Tel 08-444 14 00  
[www.elstandard.se](http://www.elstandard.se)

September 2017

ICS 17.220.20

English Version

Computation of waveform Parameter uncertainties  
(IEC 62754:2017)

Calcul des incertitudes des paramètres des formes d'onde  
(IEC 62754:2017)

Berechnung der Messunsicherheiten von  
Schwingungsabbildparametern  
(IEC 62754:2017)

This European Standard was approved by CENELEC on 2017-06-28. 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 CEN-CENELEC Management Centre 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 CEN-CENELEC Management Centre 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, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.



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

CEN-CENELEC Management Centre: Avenue Marnix 17, B-1000 Brussels

## **European foreword**

The text of document 85/585/FDIS, future edition 1 of IEC 62754, prepared by IEC/TC 85 "Measuring equipment for electrical and electromagnetic quantities" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 62754:2017.

The following dates are fixed:

- latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2018-03-28
- latest date by which the national standards conflicting with the document have to be withdrawn (dow) 2020-06-28

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

## **Endorsement notice**

The text of the International Standard IEC 62754:2017 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 standard indicated :

IEC 60359:2001                  NOTE      Harmonized as EN 60359:2002.

**Annex ZA**  
(normative)**Normative references to international publications  
with their corresponding European publications**

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

NOTE 1 When an International Publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

NOTE 2 Up-to-date information on the latest versions of the European Standards listed in this annex is available here:  
[www.cenelec.eu](http://www.cenelec.eu).

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC 60469	2013	Transitions, pulses and related waveforms - Terms, definitions and algorithms	EN 60469	2013

## CONTENTS

FOREWORD .....	4
1 Scope .....	6
2 Normative references .....	6
3 Terms and definitions .....	6
4 Waveform measurement .....	16
4.1 General .....	16
4.2 Waveform parameters .....	17
4.3 Waveform measurement process .....	17
4.3.1 General .....	17
4.3.2 General description of the measurement system .....	18
5 Waveform and waveform parameter corrections .....	19
5.1 General .....	19
5.2 Waveform parameter corrections .....	19
5.3 Waveform corrections and waveform reconstruction .....	20
5.3.1 General .....	20
5.3.2 Sample-by-sample correction .....	20
5.3.3 Entire waveform correction .....	20
6 Uncertainties .....	22
6.1 General .....	22
6.2 Propagation of uncertainties .....	22
6.2.1 General .....	22
6.2.2 Uncorrelated input quantities .....	23
6.2.3 Correlated input quantities .....	23
6.3 Pooled data and its standard deviation .....	23
6.4 Expanded uncertainty and coverage factor .....	25
6.4.1 General .....	25
6.4.2 Effective degrees of freedom .....	27
6.5 Entire waveform uncertainties .....	28
7 Waveform parameter uncertainties .....	29
7.1 General .....	29
7.2 Amplitude parameters .....	30
7.2.1 State levels .....	30
7.2.2 State boundaries .....	35
7.2.3 Waveform amplitude (state levels) .....	36
7.2.4 Impulse amplitude (state levels) .....	37
7.2.5 Percent reference levels (state levels, waveform amplitude) .....	37
7.2.6 Transition settling error (state levels, waveform amplitude) .....	38
7.2.7 Overshoot aberration (state levels, waveform amplitude) .....	38
7.2.8 Undershoot aberration (state levels, waveform amplitude) .....	39
7.3 Temporal parameters .....	39
7.3.1 Initial instant .....	39
7.3.2 Waveform epoch .....	40
7.3.3 Reference level instants (percent reference levels, waveform epoch, initial instant) .....	41
7.3.4 Impulse centre instant (impulse amplitude, reference level instants) .....	42
7.3.5 Transition duration (reference level instants) .....	42

7.3.6	Transition settling duration (reference level instants) .....	43
7.3.7	Pulse duration (reference level instants) .....	43
7.3.8	Pulse separation (reference level instants) .....	43
7.3.9	Waveform delay (advance) (reference level instants) .....	44
8	Monte Carlo method for waveform parameter uncertainty estimates .....	44
8.1	General guidance and considerations .....	44
8.2	Example: state level.....	44
Annex A (informative)	Demonstration example for the calculation of the uncertainty of state levels using the histogram mode according to 7.2.1.2.....	46
A.1	Waveform measurement .....	46
A.2	Splitting the bimodal histogram and determining the state levels .....	46
A.3	Uncertainty of state levels.....	47
Annex B (informative)	Computation of $\Sigma_L$ and $\Sigma_Y$ for estimating the uncertainty of state levels using the shorth method according to 7.2.1.3 .....	49
Bibliography.....		52
Figure 1 – Reference levels, reference level instants, waveform amplitude, and transition duration for a single positive-going transition.....		7
Figure 2 – Overshoot, undershoot, state levels, and state boundaries for a single positive-going transition .....		11
Figure 3 – Creation of measured, corrected, and reconstructed waveforms and the final estimate of the input signal.....		17
Figure 4 – Example of waveform bounds focusing on the trajectories that impact pulse parameter measurements .....		28
Figure 5 – Relationship between selected waveform parameters .....		30
Figure A.1 – Waveform obtained from the measurement of a step-like signal from which the state levels and uncertainties are calculated .....		46
Figure A.2 – Histograms of state s1 (a) and state s2 (b) of the step-like waveform plotted in Figure A.1 .....		47
Figure B.1 – Diagram showing location of waveform elements, $y_{(\beta)}^{(\alpha)}$ , in $Y_1$ and $Y_2$ , and the construction of $Y$ from $Y_1$ and $Y_2$ .....		49
Table 1 – Value of the coverage factor $k_p$ that encompasses the fraction $p$ of the $t$ - distribution for different degrees of freedom (from ISO/IEC Guide 98-3).....		26
Table 2 – Different methods for determining state levels, as given in IEC 60469, and their uncertainty type and method of computation .....		31
Table 3 – Different methods for determining state boundaries and their uncertainty type and method of computation .....		36
Table 4 – Variables contributing to the uncertainty in overshoot.....		39
Table 5 – Variables contributing to the uncertainty in the reference level instant.....		42
Table A.1 – Uncertainty contributions and total uncertainty for $level(s_i)$ determined from histogram modes .....		48

## INTERNATIONAL ELECTROTECHNICAL COMMISSION

### COMPUTATION OF WAVEFORM PARAMETER UNCERTAINTIES

#### 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 62754 has been prepared by IEC technical committee 85: Measuring equipment for electrical and electromagnetic quantities.

The text of this International Standard is based on the following documents:

FDIS	Report on voting
85/585/FDIS	85/X588/RVD

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

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

The terms used throughout this document which have been defined in Clause 3 are in italic type.

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

## COMPUTATION OF WAVEFORM PARAMETER UNCERTAINTIES

### 1 Scope

This document specifies methods for the computation of the temporal and amplitude parameters and their associated uncertainty for step-like and impulse-like waveforms. This document is applicable to any and all industries that generate, transmit, detect, receive, measure, and/or analyse these types of pulses.

### 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

IEC 60469:2013, *Transitions, pulses and related waveforms – Terms, definitions and algorithms*