IEC 60469

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INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

Transitions, pulses and related waveforms – Terms, definitions and algorithms

Transitions, impulsions et formes d'ondes associées – Termes, définitions et algorithmes

IEC 60469:2013

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TRANSITIONS, PULSES AND RELATED WAVEFORMS – TERMS, DEFINITIONS AND ALGORITHMS

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.

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International Standard IEC 60469 has been prepared by IEC technical committee 85: Measuring equipment for electrical and electromagnetic quantities.

This first edition of IEC 60469 cancels and replaces the second edition of IEC 60469-1 and the second edition of IEC 60469-2, both published in 1987. It constitutes a technical revision.

This first edition of IEC 60469:

- combines the contents of IEC 60469-1:1987 and IEC 60469-2:1987;
- updates terminology;
- adds algorithms for computing values of pulse parameters;
- adds a newly-developed method for computing state levels.

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

CDV	Report on voting
85/409/CDV	85/433/RVC

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

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

All terms defined in Clause 3 are italicized in this document.

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

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- withdrawn,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

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INTRODUCTION

The purpose of this standard is to facilitate accurate and precise communication concerning parameters of transition, pulse, and related waveforms and to establish the techniques and procedures for measuring them. Because of the broad applicability of electrical pulse technology in the electronics industries (such as computer, telecommunication, and test instrumentation industries), the development of unambiguous definitions for pulse terms and the presentation of methods and/or algorithms for their calculation is important for communication between manufacturers and consumers within the electronics industry. The availability of standard terms, definitions, and methods for their computation helps improve the quality of products and helps the consumer better compare the performance of different products. Improvements to digital waveform recorders (including oscilloscopes) have facilitated the capture, sharing, and processing of waveforms. Frequently these waveform recorders have the ability to process the waveform internally and provide pulse parameters. This process is done automatically and without operator intervention. This standard can be applied in many more scientific and engineering applications than mentioned above, such as optics, cosmology, seismology, medicine, etc., and ranging from single events to highly repetitive signals and from signals with bandwidths less than 1 Hz to those exceeding 1 THz. Consequently, a standard is needed to ensure that the definitions and methods of computation for pulse parameters are consistent.

IEC 60469-1 dealt with terms and definitions for describing waveform parameters and IEC 60469-2 described the waveform measurement process. The purpose of this standard is to combine the contents of IEC 60469-1 and IEC 60469-2, update terminology, correct errors, add algorithms for computing values of pulse parameters, and add a newly-developed method for computing state levels. This standard reflects two major changes compared to IEC 60469-1 and IEC 60469-2, which are the parameter definitions and algorithms. Changes to the definitions included adding new terms and definitions, deleting unused terms and definitions, expanding the list of deprecated terms, and updating and modifying existing definitions. This standard contains definitions for approximately 100 terms commonly used to describe the waveform measurement and analysis process and waveform parameters. Many of the terms in standards IEC 60469-1 and IEC 60469-2 have been deleted entirely or deprecated. Deprecated terms were kept in this standard to provide continuity between this standard and IEC 60469-1 and IEC 60469-2. Terms are deprecated whenever they cannot be defined unambiguously or precisely. Development of a set of agreed-upon terms and definitions presented the greatest difficulty because of the pervasive misuse, misrepresentation, and misunderstanding of terms. Legacy issues for instrumentation manufacturers and terms of common use also had to be addressed. This standard also resulted in the development of algorithms for computing the values of certain waveform parameters in all cases where these algorithms could be useful or instructive to the user of the standard. The purpose of adding these algorithms, which are recommended for use, was to provide industry with a common and communicable reference for these parameters and their computation. Heretofore, this was not available and there existed much debate and misunderstanding between various groups measuring the same parameters. Similarly, this is the reason for including several examples of basic waveforms, with formulae, in Annex A. The algorithms focus on the analysis of two-state, single-transition waveforms. The analysis of compound waveforms (waveforms with two or more states and/or two or more transitions) is accomplished by first decomposing the compound waveform into its constituent two-state single-transition waveforms. A method for performing this decomposition is provided.

Algorithms for the analysis of fluctuation and random jitter of waveforms were also introduced into this standard. These algorithms describe the computation of the mean and standard deviation of jitter and fluctuation. This standard also contains methods to estimate the *accuracy* of the standard deviation and to correct its value.

TRANSITIONS, PULSES AND RELATED WAVEFORMS – TERMS, DEFINITIONS AND ALGORITHMS

1 Scope

This International Standard provides definitions of terms pertaining to transitions, pulses, and related waveforms and provides definitions and descriptions of techniques and procedures for measuring their parameters. The waveforms considered in this standard are those that make a number of transitions and that remain relatively constant in the time intervals between transitions. Signals and their waveforms for which this standard apply include but are not limited to those used in: digital communications, data communications, and computing; studies of transient biological, cosmological, and physical events; and electrical, chemical, and thermal pulses encountered and used in a variety of industrial, commercial, and consumer applications.

This standard does not apply to sinusoidally-varying or other continuously-varying signals and their waveforms.

The object of this standard is to facilitate accurate and precise communication concerning parameters of transitions, pulses, and related waveforms and the techniques and procedures for measuring them.

2 Normative references

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.

None.

3 Terms, definitions and symbols

3.1 General

Along with the recommended terms and their definitions, this clause also contains a number of deprecated but widely used terms. These deprecated terms and the reason for their deprecation are given after the definition of the recommended term.

Throughout this standard, time is taken to be an independent variable, symbolized with the letter t. "Waveform value" is used to refer to the dependent variable, symbolized by $y(t)$. For particular waveforms, "waveform value" will be synonymous with terms such as "voltage", "current", "power", or some other quantity. All defined terms are italicized in this document.

3.2 Terms and definitions

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

3.2.1
aberration region

3.2.1.1
post-transition aberration region
interval between a user-specified *instant* and a fixed *instant*, where the fixed *instant* is the first sampling *instant* succeeding the 50 % *reference level instant* for which the corresponding *waveform* value is within the *state boundaries* of the *state* succeeding the 50 % *reference level instant*

Note 1 to entry: The user-specified *instant* occurs after the fixed *instant* and is typically equal to the fixed *instant* plus three times the *transition duration*.

3.2.1.2
pre-transition aberration region
interval between a user-specified *instant* and a fixed *instant*, where the fixed *instant* is the first sampling *instant* preceding the 50 % *reference level instant* for which the corresponding *waveform* value is within the *state boundaries* of the *state* preceding the 50 % *reference level instant*.

Note 1 to entry: The user-specified *instant* occurs before the fixed *instant* and is typically equal to the fixed *instant* minus three times the *transition duration*.

3.2.2
accuracy
closeness of agreement between a measured quantity value and a true quantity value of a measurand

[ISO/IEC Guide 99:2007, 2.13]

3.2.3
amplitude

3.2.3.1
impulse amplitude
difference between the specified *level* corresponding to the *maximum peak* (*minimum peak*) of the positive (negative) *impulse-like waveform* and the *level* of the *state* preceding the first *transition* of that *impulse-like waveform*

3.2.3.2
waveform amplitude
difference between the *levels* of two different *states* of a *waveform*

Note 1 to entry: Two different definitions for *amplitude* are authorized by this standard because they are both in common use (see 3.2.3.2.1.. In all applications of this standard, the chosen definition shall be clearly identified.:

3.2.3.3
signed waveform amplitude,
level of the *state* succeeding a *transition* minus the *level* of the *state* preceding the same *transition*

3.2.3.4
unsigned waveform amplitude
absolute value of the *signed amplitude*

3.2.4
correction
operation combining the results of the conversion operation with the transfer function information to yield a *waveform* that is a more accurate representation of the *signal*

Note 1 to entry: Correction may be effected by a manual process by an operator, a computational process, or a compensating device or apparatus. Correction shall be performed to an *accuracy* that is consistent with the overall *accuracy* desired in the *waveform measurement process*.

Note 2 to entry: See 4.2 concerning the conversion operation.

3.2.5
cycle
portion of a *periodic waveform* with a *duration* of one *period*

3.2.6
delaying
process in which the time of arrival of a *signal* is caused to occur later in time

3.2.7
differentiation
shaping process in which a *waveform* is converted to a *waveform* whose shape is or approximates the time derivative of that *waveform*

3.2.8
duration
difference between two specified *instants*

3.2.9
duty factor
DEPRECATED: duty cycle
unless otherwise specified, for a *periodic pulse train*, the ratio of the *pulse duration* to the *waveform* period

Note 1 to entry: The term duty *cycle* is a deprecated term because the word *cycle* in this standard refers to the *period* of a *signal*.

3.2.10
fluctuation
variation (dispersion) of a *level* parameter of a set of *repetitive waveforms* with respect to a *reference amplitude* or a *reference level*

Note 1 to entry: Unless otherwise specified by a mathematical adjective, root-mean-square (rms) fluctuation is assumed.

3.2.11
frequency
reciprocal of the period

Note 1 to entry: The period is the *waveform period*.

[IEC 60050-103:2009, 103-06-02, modified – the note to entry has been replaced.]

3.2.12
glitch
transient that leaves an initial *state,* enters the boundaries of another *state* for a *duration* less than the *duration* for *state occurrence*, and then returns to the initial *state*

3.2.13
instant
particular time value within a *waveform epoch* that, unless otherwise specified, is referenced relative to the *initial instant* of that *waveform epoch*

3.2.13.1
final instant
last sample *instant* in the *waveform*

3.2.13.2
impulse center instant
instant at which a user-specified approximation to the *maximum peak* (*minimum peak*) of the positive (negative) *impulse-like waveform* occurs

3.2.13.3
initial instant
first sample *instant* in the *waveform*

3.2.13.4
pulse center instant
average of the two *instants* used to calculate the pulse *duration*

3.2.13.5
reference level instant
instant at which the *waveform* intersects a specified *reference level*

3.2.13.6
transition occurrence instant
first 50 % *reference level instant,* unless otherwise specified, on the *transition* of a *step-like waveform*

SEE: Figure 1, Figure 2, Figure 3, and Figure 4.

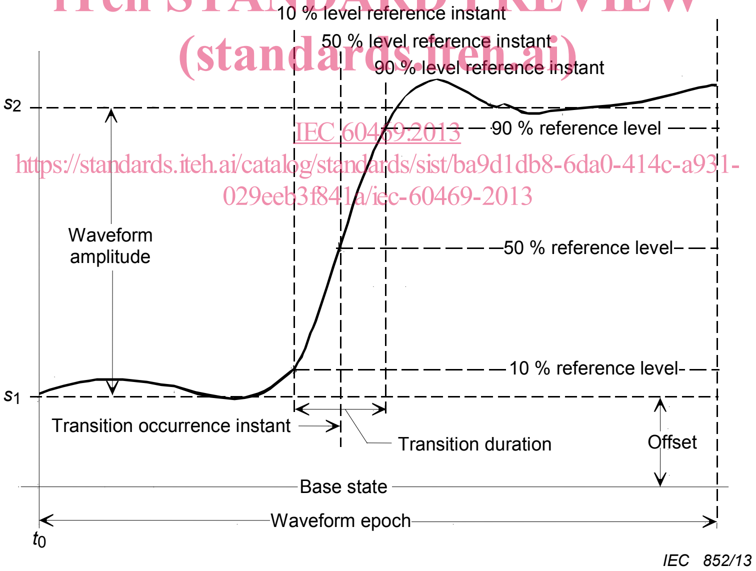

Figure 1 – Single *positive-going transition*

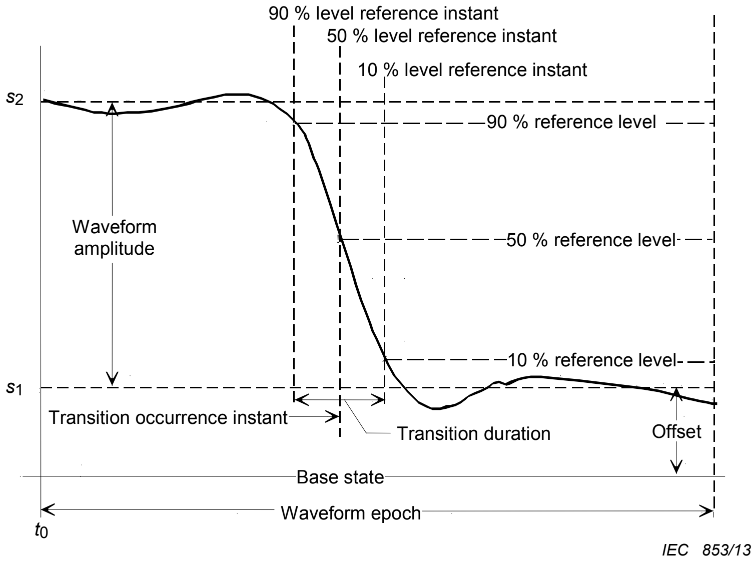

Figure 2 – Single *negative-going transition*

Note 1 to entry: See 5.3.4 concerning *reference level instants.*

3.2.14
integration
shaping process in which a *waveform* is converted to a *waveform* whose shape is or approximates the time integral of that *waveform*

3.2.15
interval
set of all values of time between a first *instant* and a second *instant*, where the second *instant* is later in time than the first.

Note 1 to entry: These first and second *instants* are called the endpoints of the interval. The endpoints, unless otherwise specified, are assumed to be part of the interval.

3.2.16
jitter
variation (dispersion) of a time parameter between successive *cycles* of a repetitive *signal* and/or between successively acquired *waveforms* of a *repetitive signal* for a given *reference level instant* or *duration*.

Note 1 to entry: Unless otherwise specified by a mathematical adjective, rms *jitter* is assumed.

3.2.16.1
cycle-to-*n*th-cycle jitter
jitter between specified *reference level instants* of any two specified *cycles* of a *repetitive signal*

3.2.16.2
period jitter
jitter in the period of a repetitive signal or its waveform

3.2.16.3
pulse duration jitter
jitter in the pulse duration of a signal or its waveform

3.2.16.4
trigger jitter
jitter between a *repetitive signal* and the trigger event that is used to generate or measure that *signal*

3.2.17
level
constant value having the same units as *y*

3.2.17.1
average level
pertaining to the value of the mean of the *waveform level*

If the *waveform* takes on *n* discrete values y_j, all equally spaced in time, the *average level* is,

$$\bar{y} = \left(\frac{1}{n}\right)\sum_{j=1}^{n} y_j .$$

If the *waveform* is a continuous function of time *y(t)*,

$$\bar{y} = \left(\frac{1}{t_2 - t_1}\right)\int_{t_1}^{t_2} y(t)dt.$$

Note 1 to entry: The summation or integral extends over the *waveform epoch* for which the average *level* is desired or, if the function is *periodic*, over any integral number of *periodic* repetitions of the function.

3.2.17.2
average absolute level
pertaining to the mean of the absolute *waveform* value

If the *waveform* takes on *n* discrete values y_j, all equally spaced in time, the average absolute *level* is,

$$\overline{|y|} = \left(\frac{1}{n}\right)\sum_{j=1}^{n} |y_j|.$$

If the *waveform* is a continuous function of time *y(t)*,

$$\overline{|y|} = \left(\frac{1}{t_2 - t_1}\right)\int_{t_1}^{t_2} |y(t)|dt.$$

Note 1 to entry: The summation or the integral extends over the *waveform epoch* for which the average absolute *level* is desired or, if the function is *periodic*, over any integral number of *periodic* repetitions of the function.

3.2.17.3
percent reference level
reference level specified by:

$$y_{x\%} = y_{0\%} + \frac{x}{100}\left(y_{100\%} - y_{0\%}\right),$$

where

0 % < *x* < 100 %

$y_{0\,\%}$ = level of low state

$y_{100\ \%}$ = level of high state

$y_{0\ \%}$, $y_{100\ \%}$, and $y_{x\ \%}$ are all in the same unit of measurement.

SEE: Figure 1, Figure 2, Figure3, and Figure 4.

Note 1 to entry: Commonly used *reference levels* are: 0 %, 10 % , 50 %, 90 %, and 100 %.

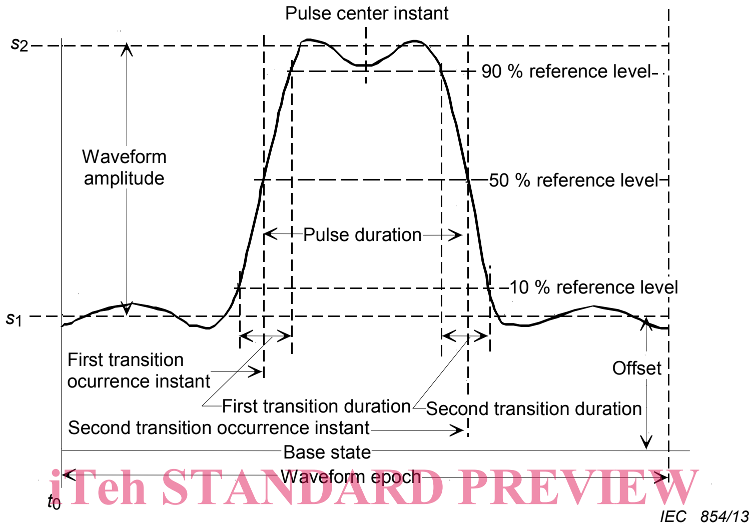

Figure 3 – Single *positive pulse waveform*

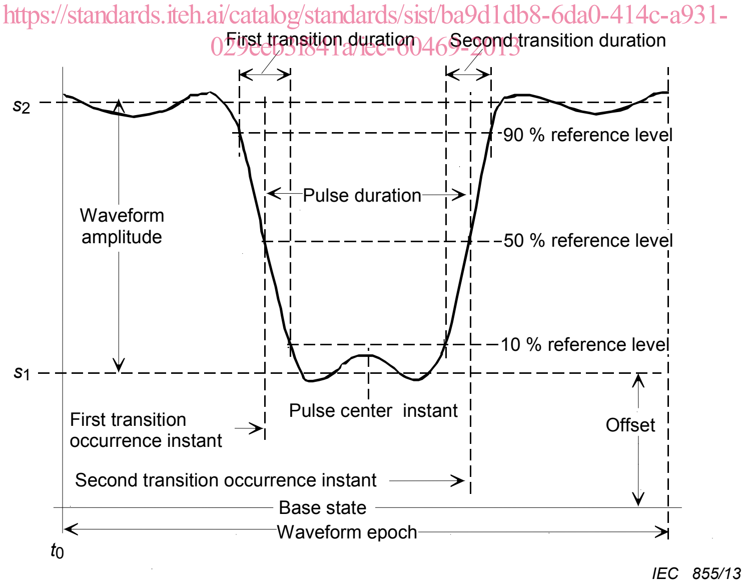

Figure 4 – Single *negative pulse waveform*

3.2.17.4
reference level
DEPRECATED: mesial, proximal, distal
user specified *level* that extends through all *instants* of the *waveform epoch*

Note 1 to entry: *Mesial*, *proximal*, and *distal* lines are deprecated terms because