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Voltage characteristics of electricity supplied by public distribution systems

Merkmale der Spannung in öffentlichen Elektrizitätsversorgungsnetzen

Caractéristiques de la tension fournie par les réseaux publics de distribution

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CENELEC

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

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Foreword

This European Standard was prepared by the CENELEC BTTF 68-6, Physical characteristics of electrical energy. The text of the draft was submitted to the Unique Acceptance Procedure and was approved by CENELEC as EN 50160 on 1994-07-05.

Three drafts for amendments (prAA, prAB, prAC) were submitted to the CENELEC formal vote and were approved by CENELEC on 1999-01-01 for inclusion into a second edition of EN 50160.

This European Standard replaces EN 50160:1994.

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) 2000-05-01
- latest date by which the national standards conflicting with the EN have to be withdrawn (dow) 2000-05-01

Annexes designated "informative" are given for information only.
In this standard, annex A is informative.

Contents

1 General

1.1 Scope

This standard gives the main characteristics of the voltage at the customer's supply terminals in public low voltage and medium voltage electricity distribution systems under normal operating conditions. This standard gives the limits or values within which any customer can expect the voltage characteristics to remain, and does not describe the typical situation for a customer connected to a public supply network.

NOTE: For the definitions of low and medium voltage see 1.3.7 and 1.3.8.

The standard does not apply under abnormal operating conditions including the following:

- conditions arising as a result of a fault or a temporary supply arrangement adopted to keep customers supplied during maintenance and construction work or to minimize the extent and duration of a loss of supply,

- in case of non-compliance of a customer's installation or equipment with the relevant standards or with the technical requirements for connection of loads, established either by the public authorities or the electricity supplier including the limits for the emission of conducted disturbances,

- in case of non-compliance of a generation installation with the relevant standards or with the technical requirements for interconnection with an electricity distribution system established either by the public authorities or the electricity supplier (e.g. embedded generation),

- in exceptional situations outside the electricity supplier's control, in particular,
  - exceptional weather conditions and other natural disasters,
  - third party interference,
  - acts by public authorities,
  - industrial actions (subject to legal requirements),
  - force majeure,
  - power shortages resulting from external events.

The voltage characteristics given in this standard are not intended to be used as electromagnetic compatibility (EMC) levels or user emission limits for conducted disturbances in public distribution systems.

The voltage characteristics given in this standard are not intended to be used to specify requirements in equipment product standards, but should be considered. It should be especially noted that the performance of equipment might be impaired if it is subjected to supply conditions which are not taken into account in the equipment product standard.

This standard may be superseded in total or in part by the terms of a contract between the individual customer and the electricity supplier.

1.2 Object

The object of this standard is to define and describe the characteristics of the supply voltage concerning:

- frequency;
- magnitude;
- wave form;
- symmetry of the three phase voltages.

These characteristics are subject to variations during the normal operation of a supply system due to changes of load, disturbances generated by certain equipment and the occurrence of faults which are mainly caused by external events.

The characteristics vary in a manner which is random in time, with reference to any specific supply terminal, and random in location, with reference to any given instant of time. Because of these variations, the levels of the characteristics can be expected to be exceeded on a small number of occasions.

Some of the phenomena affecting the voltage are particularly unpredictable, so that it is impossible to give definite values for the corresponding characteristics. The values given in this standard for such phenomena, e.g. voltage dips and voltage interruptions, shall be interpreted accordingly.

1.3 Definitions

For the purposes of this standard, the following definitions apply.

1.3.1 customer
The purchaser of electricity from a supplier.

1.3.2 supplier
The party who provides electricity via a public distribution system.

1.3.3 supply terminals
Point of connection of the customer's installation to the public system.

NOTE: This point can differ from, for example, the electricity metering point or the point of common coupling.

1.3.4 supply voltage
The rms value of the voltage at a given time at the supply terminals, measured over a given interval.

1.3.5 nominal voltage of a system (U_n)
The voltage by which a system is designated or identified and to which certain operating characteristics are referred.

1.3.6 declared supply voltage (U_c)
The declared supply voltage U_c is normally the nominal voltage U_n of the system. If by agreement between the supplier and the customer a voltage different from the nominal voltage is applied to the terminal, then this voltage is the declared supply voltage U_c.

1.3.7 low voltage (abbreviation: lv)
For the purpose of this standard a voltage, used for the supply of electricity, whose upper limit of nominal rms value is 1 kV.

1.3.8 Medium voltage (abbreviation: mv)
For the purpose of this standard a voltage, used for the supply of electricity, whose nominal rms value lies between 1 kV and 35 kV.

1.3.9 normal operating condition
For a distribution system the condition of meeting load demand, system switching and clearing faults by automatic system protection in the absence of exceptional conditions due to external influences or major events.

1.3.10 conducted disturbance
Electromagnetic phenomenon propagated along the line conductors of a distribution system. In some cases an electromagnetic phenomenon is propagated across transformer windings and hence between networks at different voltage levels. These disturbances may degrade the performance of a device, equipment or system or they may cause damage.

1.3.11 frequency of the supply voltage
Repetition rate of the fundamental wave of the supply voltage measured over a given interval of time.

1.3.12 voltage variation
An increase or decrease of voltage normally due to variation of the total load of a distribution system or a part of it.

1.3.13 rapid voltage change
A single rapid variation of the rms value of a voltage between two consecutivelevels which are sustained for definite but unspecified durations.

1.3.14 voltage fluctuation
A series of voltage changes or a cyclic variation of the voltage envelope (IEV 161-08-05).

1.3.15 flicker
Impression of unsteadiness of visual sensation induced by a light stimulus whose luminance or spectral distribution fluctuates with time (IEV 161-08-13).

NOTE: Voltage fluctuation causes changes of the luminance of lamps which can create the visual phenomenon called flicker. Above a certain threshold flicker becomes annoying. The annoyance grows very rapidly with the amplitude of the fluctuation. At certain repetition rates even very small amplitudes can be annoying.

1.3.16 flicker severity
Intensity of flicker annoyance defined by the UIE-IEC flicker measuring method and evaluated by the following quantities:

- **short term severity** (P_{st}) measured over a period of ten minutes;
- **long term severity** (P_{lt}) calculated from a sequence of 12 P_{st}-values over a two hour interval, according to the following expression:

$$P_{lt} = \sqrt[3]{\sum_{i=1}^{12} \frac{P_{sti}^{3}}{12}}$$

1.3.17 supply voltage dip

A sudden reduction of the supply voltage to a value between 90 % and 1 % of the declared voltage U_c, followed by a voltage recovery after a short period of time. Conventionally the duration of a voltage dip is between 10 ms and 1 minute. The depth of a voltage dip is defined as the difference between the minimum rms voltage during the voltage dip and the declared voltage. Voltage changes which do not reduce the supply voltage to less than 90 % of the declared voltage U_c are not considered to be dips.

1.3.18 supply interruption

A condition in which the voltage at the supply terminals is lower than 1 % of the declared voltage, U_c. A supply interruption can be classified as:

- **prearranged**, when consumers are informed in advance, to allow the execution of scheduled works on the distribution system, or

- **accidental**, caused by permanent or transient faults, mostly related to external events, equipment failures or interference. An accidental interruption is classified as:

  - **a long interruption** (longer than three minutes) caused by a permanent fault,
  - **a short interruption** (up to three minutes) caused by a transient fault.

NOTE 1: The effect of a prearranged interruption can be minimized by the customers by taking appropriate measures.

NOTE 2: Accidental supply interruptions are unpredictable, largely random events.

1.3.19 temporary power frequency overvoltage

An overvoltage, at a given location, of relatively long duration.

NOTE: Temporary overvoltages usually originate from switching operations or faults (e.g. sudden load reduction, single phase faults, non-linearities).

1.3.20 transient overvoltage

A short duration oscillatory or non-oscillatory overvoltage usually highly damped and with a duration of a few milliseconds or less.

NOTE: Transient overvoltages are usually caused by lightning, switching or operation of fuses. The rise time of a transient overvoltage can vary from less than a microsecond up to a few milliseconds.

1.3.21 harmonic voltage

A sinusoidal voltage with a frequency equal to an integer multiple of the fundamental frequency of the supply voltage. Harmonic voltages can be evaluated:

- individually by their relative amplitude (U_h) related to the fundamental voltage U_1, where h is the order of the harmonic;
- globally, for example by the total harmonic distortion factor THD, calculated using the following expression:

$$THD = \sqrt{\sum_{h=2}^{40} (u_h)^2}$$

NOTE: Harmonics of the supply voltage are caused mainly by customers' non-linear loads connected to all voltage levels of the supply system. Harmonic currents flowing through the system impedance give rise to harmonic voltages. Harmonic currents and system impedances and thus the harmonic voltages at the supply terminals vary in time.

1.3.22 interharmonic voltage

A sinusoidal voltage with a frequency between the harmonics, i.e. the frequency is not an integer multiple of the fundamental.

NOTE: Interharmonic voltages at closely adjacent frequencies can appear at the same time forming a wide band spectrum.

1.3.23 voltage unbalance

In a three-phase system, a condition in which the rms values of the phase voltages or the phase angles between consecutive phases are not equal.

1.3.24 mains signalling voltage

A signal superimposed on the supply voltage for the purpose of transmission of information in the public distribution system and to customers' premises. Three types of signals in the public distribution system can be classified:

- **ripple control signals:** superimposed sinusoidal voltage signals in the range of 110 Hz to 3000 Hz;

- **power-line-carrier signals:** superimposed sinusoidal voltage signals in the range between 3 kHz to 148,5 kHz;

- **mains marking signals:** superimposed short time alterations (transients) at selected points of the voltage waveform.

1.4 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

EN 50065-1 A1	1991 1992	Signalling on low-voltage electrical installations in the frequency range 3 kHz to 148,5 kHz Part 1: General requirements, frequency bands and electromagnetic disturbances
EN 60555-1	1987	Disturbances in supply systems caused by household appliances and similar electrical equipment – Part 1: Definitions (IEC 60555-1:1982)
EN 60868	1993	Flickermeter – Functional and design specifications (IEC 60868:1986 + A1:1990)
EN 61000-4-7	1993	Electromagnetic compatibility (EMC) Part 4-7: Testing and measurement techniques – General guide on harmonics and interharmonics measurements and instrumentation, for power supply systems and equipment connected thereto (IEC 61000-4-7:1991)

ENV 61000-2-2	1993	Electromagnetic compatibility Part 2: Environment Section 2: Compatibility levels for low-frequency conducted disturbances and signalling in public low-voltage power supply systems (IEC 61000-2-2:1990)
HD 472 S1	1989	Nominal voltages for low voltage public electricity supply systems (IEC 60038:1983, modified; title of IEC 60038: IEC standard voltages)
IEC 60050-161	1990	International Electrotechnical Vocabulary Chapter 161: Electromagnetic compatibilty
UNIPEDE 91 en 50.02		Voltage dips and short interruptions in public medium voltage electricity supply systems

2 Low-voltage supply characteristics

2.1 Power frequency

The nominal frequency of the supply voltage shall be 50 Hz. Under normal operating conditions the mean value of the fundamental frequency measured over 10 s shall be within a range of

- for systems with synchronous connection to an interconnected system

50 Hz ± 1 %	(i.e. 49,5 ... 50,5 Hz)	during 99,5 % of a year,
50 Hz + 4 %/- 6 %	(i.e. 47 ... 52 Hz)	during 100 % of the time.

- for systems with no synchronous connection to an interconnected system (e.g. supply systems on certain islands)

50 Hz ± 2 %	(i.e. 49 ... 51 Hz)	during 95 % of a week,
50 Hz ± 15 %	(i.e. 42,5 ... 57,5 Hz)	during 100 % of the time.

2.2 Magnitude of the supply voltage

The standard nominal voltage U_n for public low voltage is:

- for four-wire three phase systems:
  U_n = 230 V between phase and neutral,

- for three-wire three phase systems:
  U_n = 230 V between phases.

NOTE 1: Until the year 2003 the nominal voltage may differ from 230 V in accordance with HD 472 S1.

NOTE 2: In low voltage systems declared and nominal voltage are equal.