SLOVENSKI STANDARD
SIST EN 50160:2008

01-junij-2008

Nadomešča:
SIST EN 50160:2000

Značilnosti napetosti v javnih distribucijskih omrežjih

Voltage characteristics of electricity supplied by public distribution networks

Merkmale der Spannung in öffentlichen Elektrizitätsversorgungsnetzen

Caractéristiques de la tension fournie par les réseaux publics de distribution

Ta slovenski standard je istoveten z: **EN 50160:2007**

ICS:

29.240.01	Omrežja za prenos in distribucijo električne energije na splošno	Power transmission and distribution networks in general

SIST EN 50160:2008 **en,fr**

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 50160

September 2007

ICS 29.020

Supersedes EN 50160:1999

English version

Voltage characteristics of electricity supplied by public distribution networks

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CENELEC

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

Central Secretariat: rue de Stassart 35, B - 1050 Brussels

Ref. No. EN 50160:2007 E

Foreword

This European Standard was prepared by the Working Group 1, Physical characteristics of electrical energy, of the Technical Committee CENELEC TC 8X, System aspects for electrical energy supply.

The text of the draft was submitted to the formal vote and was approved by CENELEC as EN 50160 on 2007-06-01.

This European Standard supersedes EN 50160:1999 + corrigendum September 2004.

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)	2008-06-01
– latest date by which the national standards conflicting with the EN have to be withdrawn	(dow)	2010-06-01

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1 Scope and object

1.1 Scope

This European Standard defines, describes and specifies the main characteristics of the voltage at a network user's supply terminals in public low voltage and medium voltage electricity distribution networks under normal operating conditions. This standard describes the limits or values within which the voltage characteristics can be expected to remain over the whole of the public distribution network and does not describe the average situation usually experienced by an individual network user.

NOTE 1 For the definitions of low and medium voltage see 3.7 and 3.8.

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

– a temporary supply arrangement to keep the network users supplied during condition arising as a result of a fault, maintenance and construction work or to minimize the extent and duration of a loss of supply;

– in case of non-compliance of a network user's installation or equipment with the relevant standards or with the technical requirements for connection, established either by the public authorities or the distribution network operator (DNO) including the limits for the emission of conducted disturbances;

NOTE 2 A network user's installation may include load as well as generation.

– in exceptional situations, 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 networks.

The voltage characteristics given in this standard are not intended to be used to specify requirements in equipment product standards and in installation standards.

NOTE 3 The performance of equipment might be impaired if it is subjected to supply conditions which are not specified in the equipment product standard.

This standard may be superseded in total or in part by the terms of a contract between the individual network user and the DNO.

1.2 Object

The object of this European Standard is to define and describe the characteristics of the supply voltage concerning

– frequency,
– magnitude,
– wave form,
– symmetry of the line 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, which make it very difficult to give useful 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.

2 Normative references

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.

IEC 60050-161	International Electrotechnical Vocabulary - Chapter 161: Electromagnetic compatibility

3 Definitions

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

3.1
network user
party being supplied by or supplying to an electricity distribution network

3.2
distribution network operator (DNO)
party responsible for operating, ensuring the maintenance of and, if necessary, developing the distribution network in a given area and, for ensuring the long term ability of the network to meet reasonable demands for the distribution of electricity

3.3
supply terminal
point in a distribution network designated as such and contractually fixed, at which electrical energy is exchanged between contractual partners

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

3.4
supply voltage
r.m.s. value of the voltage at a given time at the supply terminal, measured over a given interval

3.5
nominal voltage (U_n)
voltage by which a distribution network is designated or identified and to which certain operating characteristics are referred

3.6
declared supply voltage (U_c)
the declared supply voltage U_c is normally the nominal voltage U_n of the distribution network. If by agreement between the DNO and the network user a voltage different from the nominal voltage is applied to the terminal, then this voltage is the declared supply voltage U_c

3.7
low voltage (LV)
for the purpose of this European Standard, voltage whose upper limit of nominal r.m.s. value is 1 kV

3.8
medium voltage (MV)
for the purpose of this European Standard, voltage whose nominal r.m.s. value lies above 1 kV and below 35 kV

3.9
normal operating condition
for a distribution network, condition of meeting load and generation demands, system switching and clearing faults by automatic system protection in the absence of exceptional conditions due to external influences or major events

3.10
conducted disturbance
electromagnetic phenomenon propagated along the line conductors of a distribution network. In some cases an electromagnetic phenomenon is propagated across transformer windings and hence between networks of different voltage levels. These disturbances may degrade the performance of a device, equipment or system or they may cause damage

3.11
frequency of the supply voltage
repetition rate of the fundamental wave of the supply voltage measured over a given interval of time

3.12
voltage variation
increase or decrease of voltage normally due to load variations

3.13
rapid voltage change
single rapid variation of the r.m.s. value of a voltage between two consecutive levels which are sustained for definite but unspecified durations (for more information see EN 61000-3-3)

3.14
voltage fluctuation
series of voltage changes or a cyclic variation of the voltage envelope

[IEV 161-08-05]

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.

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:

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

3.17
supply voltage dip
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 min. The depth of a voltage dip is defined as the difference between the minimum r.m.s. 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

3.18
supply interruption

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 network users are informed in advance, to allow the execution of scheduled works on the distribution network, 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);

  – a short interruption (up to three minutes).

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

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

3.19
temporary power frequency overvoltage
overvoltage, at a given location, of relatively long duration (see CLC/TR 50422, Clause 3 for more information)

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

3.20
transient overvoltage
short duration oscillatory or non-oscillatory overvoltage usually highly damped and with a duration of a few milliseconds or less

[IEV 604-03-13 modified]

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.

3.21 harmonic voltage

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 network users' non-linear loads connected to all voltage levels of the supply network. Harmonic currents flowing through the network impedance give rise to harmonic voltages. Harmonic currents and network impedances and thus the harmonic voltages at the supply terminals vary in time.

3.22
interharmonic voltage

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.

3.23
voltage unbalance

condition in a polyphase system in which the r.m.s. values of the line-to-line voltages (fundamental component), or the phase angles between consecutive line voltages, are not all equal. The degree of the inequality is usually expressed as the ratios of the negative and zero sequence components to the positive sequence component

[IEV 161-08-09 modified]

NOTE 1 In this European Standard, voltage unbalance is considered in relation to three-phase systems and negative phase sequence only.

NOTE 2 Several approximations give reasonably accurate results for the levels of unbalance normally encountered (ratio of negative to positive sequence components), e.g.:

$$\text{voltage unbalance} = \sqrt{\frac{6 \times (U_{12}^2 + U_{23}^2 + U_{31}^2)}{(U_{12} + U_{23} + U_{31})^2} - 2}$$

where U_{12}, U_{23} and U_{31} are the three line-to-line voltages.

3.24
mains signalling voltage

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

– **ripple control signals:** superimposed sinusoidal voltage signals in the range of 110 Hz to 3 000 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.

4 Low-voltage supply characteristics

4.1 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 Hz... 50,5 Hz) during 99,5 % of a year;
  50 Hz + 4 % / - 6 % (i.e. 47 Hz... 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 Hz... 51 Hz) during 95 % of a week;
  50 Hz ± 15 % (i.e. 42,5 Hz... 57,5 Hz) during 100 % of the time.

4.2 Magnitude of the supply voltage

The standard nominal voltage U_n for public low voltage is U_n = 230 V, either between phase and neutral, or between phases

– 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 In low voltage systems declared and nominal voltage are equal.

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4.3 Supply voltage variations

4.3.1 Requirements

The voltage variation should not exceed ± 10 %.

Situations like those arising from faults or voltage interruptions, the circumstances of which are beyond the reasonable control of the parties, are excluded.

NOTE 1 Overall experience has shown, that sustained voltage deviations of more than ± 10 % over a longer period of time are extremely unlikely, although they could theoretically be within the given statistical limits of 4.3.2. Therefore, in accordance with relevant product and installation standards and application of IEC 60038 end users' appliances are usually designed to tolerate supply voltages of ± 10 % around the nominal system voltage, which is sufficient to cover an overwhelming majority of supply conditions. It is expected to be neither technically nor economically viable to generally give appliances the ability to handle supply voltage tolerances broader than ± 10 %. If, in single cases, evidence is given, that the magnitude of the supply voltage could depart beyond this limit for a longer period of time, additional measures should be taken in cooperation with the local network operator, depending on a risk assessment. The same applies in cases, where specific appliances have an increased sensitivity with respect to voltage variations.

NOTE 2 In cases of electricity supplies in remote areas with long lines or not connected to a large interconnected network, the voltage could be outside the range of U_n + 10 % / - 15 %. Network users should be informed of the conditions.