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Voltage characteristics of electricity supplied by public distribution systems

Caractéristiques de la tension fournie par les réseaux publics de distribution

Merkmale der Spannung in öffentlichen Elektrizitätsversorgungsnetzen

CENELEC

European Committee for Electrotechnical Standardization
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Foreword

This European Standard was prepared by the Working Group 1, Physical characteristics of electrical energy of CENELEC TC 8X, System aspects of electrical energy supply. It is submitted to the CENELEC enquiry.

If ratified, this European Standard will supersede EN 50160:1999 + corrigendum September 2004.

CS note Before voting stage, this draft will have to be restructured according to the Internal Regulations, Part 3, regarding the following clauses: Normative references (Clause 2) and Definitions (Clause 3).

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1 General

1.1 Scope

This standard gives the main characteristics of the voltage at a network user'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 the voltage characteristics can be expected to remain, and does not describe the typical situation in a public supply network.

NOTE For the definitions of low and medium voltages 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 network users 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 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 A network user's installation may include load as well as generation.

- in exceptional situations outside the DNO'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..

NOTE 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 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, which make it 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
network user
party being supplied by or supplying to an electricity distribution network

1.3.2
distribution network operator (DNO)
party responsible for operating, ensuring the maintenance of and, if necessary, developing the distribution system in a given area and, for ensuring the long term ability of the system to meet reasonable demands for the distribution of electricity

1.3.3
supply terminal
a 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.

1.3.4
supply voltage
the r.m.s. value of the voltage at a given time at the supply terminal, measured over a given interval

1.3.5
nominal voltage (U_n)
the voltage by which a distribution network 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 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

1.3.7
low voltage (abbreviation: LV)
for the purpose of this standard a voltage, whose upper limit of nominal r.m.s. value is 1 kV

1.3.8
medium voltage (abbreviation: MV)
for the purpose of this standard a voltage, whose nominal r.m.s. value lies above 1 kV and below 35 kV

1.3.9
normal operating condition
for a distribution network the 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

1.3.10
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

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 r.m.s. value of a voltage between two consecutive levels which are sustained for definite but unspecified durations

1.314
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 10 min;

- **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 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

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 network users 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 min) caused by a permanent fault,
  - a short interruption (up to three min) caused by a transient fault

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.

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 ms 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 µs up to a few ms.

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_n) 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 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 r.m.s. 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 network users' 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 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

1.4 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 60038	1983	IEC standard voltages
+ A1	1994	
+ A2	1997	
IEC 60050-161	1990	International Electrotechnical Vocabulary - Chapter 161: Electromagnetic compatibility
+ A1	1997	
+ A2	1998	

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 In low voltage systems declared and nominal voltage are equal.

2.3 Supply voltage variations

2.3.1 Requirements

Under normal operating conditions the voltage variation should not exceed ± 10 %.