SLOVENSKI STANDARD
SIST-TP CLC/TR 50422:2014

01-julij-2014

Vodilo za uporabo evropskega standarda EN 50160

Guide for the application of the European Standard EN 50160

Leitfaden zur Anwendung der Europäischen Norm EN 50160

Guide d'application de la Norme Européenne EN 50160

Ta slovenski standard je istoveten z: **CLC/TR 50422:2013**

ICS:

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

SIST-TP CLC/TR 50422:2014 **en,fr**

TECHNICAL REPORT

RAPPORT TECHNIQUE

TECHNISCHER BERICHT

CLC/TR 50422

September 2013

ICS 29.020

Supersedes CLC/TR 50422:2003 + corr. Jun.2005

English version

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This Technical Report was approved by CENELEC on 2013-07-22.

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CENELEC
European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
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Ref. No. CLC/TR 50422:2013 E

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Foreword

This document (CLC/TR 50422:2013) has been prepared by CLC/TC 8X "System aspects of electrical energy supply".

This Technical Report, prepared by TF 8 of CLC/TC 8X/WG 1 "Physical characteristics of electrical energy", is based on CLC/TR 50422:2003 (first edition) [4] and the development having taken place since.

This document supersedes CLC/TR 50422:2003 + corrigendum June 2005.

CLC/TR 50422:2013 includes the following significant technical changes with respect to CLC/TR 50422:2003: this second edition has been extended, with regard to

— the inclusion of high voltage (HV) supply in the Standard,

— the relation between EN 50160 and other standards,

— the choice of power quality (PQ) values and related probabilities,

— actual trends in network use, which might lead to further development of the Standard.

For the purpose of this Technical Report, “the Standard” refers to EN 50160:2010 [8]. Likewise, “the Guide” refers to this Application Guide, CLC/TR 50422:2013.

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.

This document has been prepared under a mandate given to CENELEC by the European Commission and the European Free Trade Association.

Introduction

By its very nature, a standard has to be concise and cannot give a comprehensive background of the subject being dealt with. It was accordingly decided to prepare a guide providing additional information and clarification of the Standard, whose first edition was published in 1994. The recent Application Guide represents the 2nd edition of such a guide, which considers the development of the Standard having taken place since the publication of the 1st edition..

1 Scope

The aim of this Technical Report is to provide background information and explanations on EN 50160 with regard to the history of its development as well as to its correct application.

2 Historical overview of the Standard and its development

2.1 Historical development

The very first document dealing with some set of PQ characteristics – and therefore the origin of a related European Standard some 13 years later – was an article published by the International Union of Producers and Distributors of Electric Energy (UNIPEDE) in their magazine “Electricity Supply”, in May 1981 [32]. Experts of UNIPEDE WG “DISPERT” were commissioned “to define the different kinds of disturbances, which can affect LV distribution voltage, caused by periodical or transient phenomena, resulting in overvoltages, voltage dips, or other kinds of irregularities in the voltage wave”.

This document was prepared on the basis of information collected by European distributors, for the purpose of providing information to network users fed from LV systems and to appliance designers on the actual characteristics of the voltage distributed. It provided information about a set of characteristics:

— being recognised as representing the main irregularities in the LV supply voltage;

— being assumed as covering about 95 % of the cases;

— representing real supply voltage characteristics, to be taken into account at designing electrical and electronic equipment with respect to their undegraded operation on mains supply;

— not intended to represent limit values, but with a view to acceptable values,

distinguished in four groups:

a) (quasi)stationary phenomena, mostly with close relation to 50 Hz:

   — slow voltage variations;

   — frequency variation;

   — unbalance of three-phase voltages;

   — harmonic voltage distortion;

   — sudden voltage changes;

   — DC component;

b) caused by occasional transient phenomena:

   — voltage dips;

   — transient voltage depressions;

   — spikes originating in the operation of electrical equipment;

   — surges of atmospheric origin;

c) ripple control signals (or similar);

d) HF signals.

The existing levels of harmonic distortion, which were later used as the basis for the voltage characteristics of harmonics, were published in 1981 in a paper published by the International Council on Large Electric Systems (CIGRE) [29].

Eight years later, in September 1989, UNIPEDE published document DISNORM 12 [33],

- which kept the main principles of the afore-mentioned document, in particular the consideration of a remaining "low probability – approximately 5 % – to find the characteristics in question",
- laying down the values of the supply voltage at the supply terminals which may reasonably be expected under the present state of technologies,
- by grouping the considered set of characteristics into the 4 groups:
  1) frequency;
  2) magnitude of the voltage wave;
  3) voltage waveform;
  4) symmetry of the three-phase system.

In 1991, the European Commission (EC) published two Directives that subsequently led to an EC request to CENELEC to work out (a) related standard(s):

i) Directive 85/374/EEC on the liability for defective products [41],

specifying amongst others that "the producer shall be liable for damage caused by a defect in his product", and that " 'product' includes electricity."

ii) Directive 89/336/EEC on the electromagnetic compatibility [42];

specifying amongst others that Member states are "responsible for ensuring that electric energy distribution networks are protected from electromagnetic disturbance which can affect them and, consequently, equipment fed by them".

Additionally, two further aspects as being mentioned in the related Draft request to CENELEC as of 11 January 1991 were to be considered:

I) the development of electronic components in electrical equipment, in particular power electronics which are bringing about a relative deterioration in the quality of "electricity" as a product, while at the same time there is an increase in the level of network users' requirements;

II) widely varying regulations, specifications or contracts in force in the various Member States from one to another.

The related Draft request to CENELEC required the preparation of (a) European Standard(s)

— giving the physical characteristics [1)] of electricity supplied by low, medium and high voltage public distribution networks,

— on the basis of UNIPEDE DISNORM 12 [33],

— by trying to comply with international standards and in particular IEC standards as far as possible.

With involvement of manufacturers, network operators and consultants, CENELEC BT set up BTTF 68-6, whose result, the first edition of EN 50160, was ratified on 5 July 1994 [5]. As a first step, this standard dealt with PQ on LV and MV level (see 2.4).

According to the originally given task of describing physical characteristics of the electricity, the values given in this first edition of EN 50160 [5] represented PQ levels, which can be expected to be present at the supply terminals in Europe.

With the next editions [6] and [7], since the establishment of CLC/TC 8X/WG 1 by CLC/TC 8X (System aspects of electricity supply), EN 50160 experienced some actualisation. Related development was intensified when the Council of European Energy Regulators (CEER) joined this CENELEC work in 2006, leading to the present edition 2010 of EN 50160 [8], which is the base of this Technical Report.

With regard to the quite complex characteristics of electricity, it was deemed necessary to provide explanations to its background as well as to its specifications in more detail. That was done at first by UNIPEDE, who published a first Application Guide to the European Standard EN 50160 in January 1995 [34], followed by a related Eurelectric publication in July 1995 [30]. In 2003, CENELEC published CLC/TR 50422:2003 (edition 1), experiencing one Corrigendum in June 2005 [4].

During a phase of further developing EN 50160, some major changes took place, which were to be considered at related standardisation work:

— Move from the LV nominal voltage 220 V to 230 V U_n for continental Europe, and from 240 V to 230 V for the UK, according to HD 472 S1:1989 [16]. With consideration of some transition periods, this HD specified the nominal voltage U_n in Europe with 230 V on from 01/01/1996 at latest; for reaching the voltage band of U_n ± 10 %, finally, with corrigendum February 2002 to HD 472 S1:1989, a deadline of 01/01/2009 was specified.

— Extension of CENELEC membership from the National Committees from 18 countries [2)] in 1994 to those of 33 countries in 2013 [3)].

— Increase of the application of electronic components in electrical equipment and installations and therefore of related emissions into the supply network.

— Increase of the susceptibility of electrical equipment and installations to disturbing voltage components.

— Increase of network users' requirements on power quality.

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1) Frequency, magnitude of the voltage wave (slow variations of the voltage level, rapid variations of the voltage level, voltage dips, 50 Hz overvoltage, transient overvoltage), harmonics, unbalance, voltage interruptions, signal transmissions through the network.

2) AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IS, IT, LU, NL, NO, PT, SE

3) AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MK, MT, NL, NO, PL, PT, RO, SE, SI, SK, TR

An important change in the European electricity industry has been the deregulation of the electricity market by introducing open competition for production and sale of electricity while at the same time introducing a natural and regulated monopoly in the form of the electricity network operators. According to European Directive 2009/72/EC [3] the role of national regulatory authorities is amongst others “setting and approving standards and requirements for quality of supply” which has resulted in a stronger engagement of regulatory authorities in power quality issues on national as well as on European level, for example resulting in a cooperation between the European Energy Regulators and CENELEC.

2.2 Structure

On from the very beginning of PQ specifications, i.e. when UNIPEDE published their „Characteristics of the Low Voltage Electricity Supply“ in 1981 [32] and their Application Guide to EN 50160 [34], it was recognised that such specifications would deal with a quite specific product, showing particular characteristics, somehow different from any other product (see 3.7.1). Informative **Annex A** of EN 50160:2010 [8] provides related information in more detail.

Contrary to the primary perception of electricity, which might be described by parameters like continuity, voltage magnitude and frequency, there are lots of PQ characteristics when considering electricity supply in detail. On from the first publications by UNIPEDE, an appropriate choice out of this number of PQ characteristics has been made for being dealt with as the main characteristics of the supply voltage.

Considering PQ phenomena, a classification can be made based on different principles, e.g. on

— the predictability of phenomena affecting the voltage, enabling the specification of definite values for the corresponding characteristics.

That leads to a classification in definite and indicative values,

— the – more or less, to some degree given – continuity of occurrence of phenomena.

That leads to a classification in continuous phenomena and in events.

UNIPEDE started with a classification similar to the first example, which was kept for the EN 50160 editions from 1994 to 2007. Table 1 shows the classification as it was used in the first edition of EN 50160 as of 1994.

Table 1 — Classification of PQ phenomena according to EN 50160:1994 [5] – Definite and indicative values

Definite values	Indicative values
Power frequency	Supply voltage dips
Magnitude of the supply voltage variations	Short interruptions of the supply voltage
	Long interruptions of the supply voltage
Rapid voltage changes including flicker severity	Temporary power frequency overvoltages
Unsymmetry	Transient overvoltages
Harmonic voltage	Interharmonic voltage
	Mains signalling voltages on the supply voltage

After edition 2007, the classification of PQ phenomena for EN 50160 has been changed to a distinction between

- continuous phenomena, i.e. deviations from the nominal value that occur continuously over time. Such phenomena occur mainly due to load pattern, changes of load, non-linear loads or distributed generation,

- voltage events, i.e. sudden and significant deviations from normal or desired weave shape which typically occur due to unpredictable events (e.g. faults) or to external causes (e.g. weather conditions, third party actions, force majeure)

See Table 2 for the classification used in the Standard. The classification is independent of the cause of the phenomenon, but continuous phenomena mainly occur due to load patterns, changes in load or non-linear load whereas voltage events typically occur due to unpredictable events (e.g. faults) or to external causes (e.g. weather conditions, third party actions, force majeure).

Table 2 — Classification of PQ phenomena according to EN 50160:2010 [8] – Continuous phenomena and voltage events

Continuous phenomena	Voltage events
Variations in power frequency	Interruptions of the supply voltage
Supply voltage variations	Supply voltage dips
Rapid voltage changes including those resulting in light flicker	Supply voltage swells
Supply voltage unbalance	Transient overvoltages
Harmonic voltage	
Interharmonic voltage	
Mains signalling voltages	

EN 50160:2010 [8] gives limits for most continuous phenomena. No limits are given for single rapid voltage changes and for interharmonics.

Only indicative values for voltage events are given in EN 50160:2010 [8] pending the gathering of additional information from actual measurements and other investigations.

In EN 50160:2010 [8], an Informative Annex provides information about

a) indicative values currently available at a European level for some of the events defined and described in the Standard,

b) the way of using these values,

c) recommendations for the way of collecting further measurement data, in order to allow for comparisons between different systems and for obtaining homogeneous data at a European level.

2.3 New versions of EN 50160. A move towards limits and requirements

As explained in 2.1, the objective for EN 50160 was to establish (a) standard(s) giving the physical characteristics of electricity energy supplied by low, medium and high voltage public distribution networks, similar to the formerly published document DISNORM 12 of UNIPEDE, complying with inter-national standards and in particular IEC standards as far as possible.

When considering the development from the very first UNIPEDE document dated 1981 to the first edition of EN 50160, already some movement in the meaning of values – at least from the chosen terminology – can be recognised. While, considering the cases, where values are specified, except irregularities caused by occasional transient phenomena,

a) the 1981 UNIPEDE document uses wording like “should not differ” (e.g. slow voltage variations), “does not vary by more” (e.g. frequency variation), “values which the distributors endeavour not to exceed” (e.g. harmonics), “are usually …” (e.g. voltage changes)

b) UNIPEDE DISNORM 12 explicitly talks of “values” at the supply terminals, which “are” (e.g. frequency), “is usually” (e.g. unbalance), “will generally be lower” (e.g. 50 Hz overvoltages), represent a “normal limit which may be exceeded” (e.g. rapid variations), figure as “compatibility levels” (e.g. harmonics),

c) EN 50160:1994 – for definite values – uses a somehow more distinct wording, giving information about values which under normal operating conditions are not exceeded with a certain probability, i.e. between 95 % and 100 % of the averaging times during an observation period (see 3.1, 3.2),

all three documents having a really **describing character**.

With the following versions, besides

— the extension of the scope also to HV (see 2.4) and

— the phenomena dealt with

  — in principle (voltage swells on from 2010)

  — in more detail (e.g. voltage dips and swells),

the standard tends to have more and more set limits, with decreasing probabilities of it being exceeded, e.g.

- frequency for systems with synchronous connection to an interconnected system,

- slow voltage variations (drop of exception for remote areas for LV, decrease of residual probability for variations of U_n outside the limits of $U_n \pm 10$ %),

with the increasing meaning of distinct **requirements the network operator shall meet.**

2.4 HV chapter

HV was one of the voltage levels addressed by the European Commission (EC) in their Draft request to CENELEC in 1991. From the practical point of view, at this time – not only but also with regard to the very small number HV customers, compared with MV and, in particular, LV customers – HV appeared as less important for getting a specification of PQ characteristics; following to that, the first edition of EN 50160 was worked out for the voltage levels LV and MV only.

In the meantime, due to liberalisation and, resulting from that, the separation of distribution network operators as well as of generating companies from transmission system operators, for regulatory as well as for contractual purposes the specification of PQ characteristics for the interface to HV systems got some more importance, although the number of related complaints was quite limited. The interface with HV systems concerns different types of network users: large industrial installations, production units and distribution networks. With regard to the lack of related EN 50160 specifications, as a first step related questions were sometimes dealt with by referring to EN 50160 with recommending to apply it using the specifications of the Standard for lower voltage levels, either using the same limits or with some correction made.

After edition 2007 of EN 50160, with due regard to meshed network structures of transmission systems being somehow different from LV and MV networks, it was decided to extend the scope of EN 50160 from LV and MV also to higher voltages. For the purpose of EN 50160, PQ should be described for the supply terminals in