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Assessment of power quality - Characteristics of electricity supplied by public networks

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Assessment of power quality - Characteristics of electricity supplied by public networks

FOREWORD

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IEC TS 62749 has been prepared by IEC technical committee 8: System aspects of electrical energy supply. It is a Technical Specification.

This third edition cancels and replaces the second edition published in 2020. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) clarification that harmonic orders recommended in this document are up to 40th;
   4.6 is modified accordingly;
b) iteration that this document does not apply for systems operated above 230 kV;
c) deletion of Annex C;
d) improvement of 4.10;

e) update of profiles and addition of new profiles;

f) modifications to align with EN 50160:2022 and EN 50160:2022/AMD1:2025.

The text of this Technical Specification is based on the following documents:

Draft	Report on voting
8/1779/DTS	8/1800/RVDTS

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

The language used for the development of this Technical Specification is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

– reconfirmed,

– withdrawn, or

– revised.

INTRODUCTION

The description of electricity is of fundamental importance within electricity supply systems. In the past, its characteristics depended less on its generation than on the way in which it was transported by networks and being used by the equipment of the multiple users. Faults or other events such as short-circuit and lightning strikes occurring within users' installations or public networks also disturb or degrade it.

Nowadays, smart grid construction and massive deployment of renewable energy sources increase the complexity of power quality management. For more information about power quality issues related to distributed generation and micro-grids, refer to Annex C.

NOTE For more information about role of stakeholders for power quality management, see Annex G.

There is a need for a common set of power quality (PQ) indices and measurement methods in order to allow different system operators to measure and report power quality in a consistent manner.

Regarding the limits or levels of power quality, the situation differs. Historically, the electrical systems in different countries or regions have been designed in different ways to cater for national or regional variations like different geographic, climatic or commercial conditions, etc. It is thus essential that any set of internationally agreed power quality limits or levels also recognize these differences, which depends namely on the system configuration, the transfer characteristics between the different voltage levels (attenuation or amplification), the actual disturbance levels on the system, etc.

Also, the quality of power is not absolute. Optimizing power quality should be carried out in a cost-effective manner to balance network user power quality requirements and willingness to pay for it with power quality supply costs.

Therefore, some of the objectives recommended hereafter allow for a range of values, or options, while still ensuring the coordination of disturbance levels between different parts of the system or voltage levels.

Then, the requirements to be applied can be expressed by the association of the IEC power quality framework from the normative part of this document and profiles. Examples of profiles are given in Annex A.

1 Scope

This document, which is a Technical Specification, specifies the expected characteristics of electricity at the point of supply of public low, medium and high voltage, 50 Hz or 60 Hz, networks, as well as power quality assessment methods.

This document does not apply for systems operated above 230 kV.

The boundaries between the various voltage levels can be different for different countries or regions. In the context of this document, the following terms for system voltage are used:

– low voltage (LV) refers to U_N ≤ 1 kV;

– medium voltage (MV) refers to 1 kV < U_N ≤ 35 kV;

– high voltage (HV) refers to 35 kV < U_N ≤ 230 kV.

Because of existing network structures, in some countries or regions, the boundary between medium and high voltage can be different. This document applies to the phenomena listed in Table 1.

Table 1 – Classification of electromagnetic phenomena addressed by power quality indices

Continuous phenomena	Discontinuous phenomena – Events	Other phenomena
Frequency deviation	Supply interruption	Mains communicating voltages
Supply voltage deviation	Voltage dip	
Voltage unbalance	Voltage swell	
Harmonic voltage	Transient overvoltage	
Interharmonic voltage	Rapid voltage change	
Flicker (voltage fluctuation)		

NOTE 1 Specification of related measurement methods can be found in IEC 61000-4-30.

NOTE 2 Specification of the performance of related measuring instruments can be found in the IEC 62586 series.

NOTE 3 For information on power quality phenomena at low voltage direct current (LVDC) network, refer to IEC TR 63282.

While power quality is related to EMC in a number of ways, especially because compliance with power quality requirements depends on the control of cumulative effect of electromagnetic emission from all or multiple equipment and installations, this document is not an EMC publication (see also Annex E).

2 Normative references

There are no normative references in this document.

3 Terms and definitions

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

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

– IEC Electropedia: available at https://www.electropedia.org/

– ISO Online browsing platform: available at https://www.iso.org/obp

NOTE Terms are listed in alphabetical order.

3.1
code
collection of rules concerning rights and duties of the parties involved in a certain part of the electric power system

EXAMPLE Grid code, distribution code, code in electric power system.

[SOURCE: IEC 60050-617:2009, 617-03-03, modified – The domain has been removed, the note has been converted to an example, and the words "code in electric power system" has been added to the example.]

3.2
connection agreement
agreement entered between the system operator and a system user which governs the procedure and conditions for connection

[SOURCE: IEC 60050-617:2009, 617-04-03]

3.3
declared supply voltage
U_c
supply voltage agreed by the network operator and the network user

Note 1 to entry: Generally declared supply voltage U_c is the nominal voltage U_N but it may be different according to the agreement between the network operator and the network user.

3.4
electricity
set of the phenomena associated with electric charges and electric currents

Note 1 to entry: In the context of electric power systems, electricity is often described as a product with particular characteristics.

[SOURCE: IEC 60050-121:1998, 121-11-76, modified – The note to entry has been added.]

3.5
electromagnetic environment
totality of electromagnetic phenomena existing at a given location

Note 1 to entry: In general, the electromagnetic environment is time-dependent and its description can need a statistical approach.

[SOURCE: IEC 60050-161:2018, 161-01-01]

3.6
electromagnetic disturbance
electromagnetic phenomenon that can degrade the performance of a device, equipment or system, or adversely affect living or inert matter

Note 1 to entry: An electromagnetic disturbance can be an electromagnetic noise, an unwanted signal or a change in the propagation medium itself.

Note 2 to entry: Electromagnetic disturbance in this document refers to low frequency conducted phenomena.

[SOURCE: IEC 60050-161:2018, 161-01-05, modified – Note 2 to entry has been replaced and Note 3 to entry has been deleted.]

3.7
electromagnetic compatibility
ability of equipment or a system to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbances to anything in that environment

[SOURCE: IEC 60050-161:2018, 161-01-07]

3.8
electromagnetic compatibility level
compatibility level
specified electromagnetic disturbance level used as a reference level for co-ordination in the setting of emission and immunity limits

Note 1 to entry: By convention, the compatibility level is chosen so that there is only a small probability that it will be exceeded by the actual disturbance level.

[SOURCE: IEC 60050-161:1990, 161-03-10, modified – Note 1 has been shortened and Note 2 has been deleted]

3.9
flagged data
data that has been marked to indicate that its measurement or its aggregation can have been affected by interruptions, dips, or swells

[SOURCE: IEC 61000-4-30:2015, 3.5, modified – The definition has been reformulated to better understand the term.]

3.10
flicker
impression of unsteadiness of visual sensation induced by a light stimulus whose luminance or spectral distribution fluctuates with time

Note 1 to entry: Voltage fluctuation cause 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.

Note 2 to entry: For the time being, flicker is qualified based on incandescent lamp's behaviour.

[SOURCE: IEC 60050-161:1990, 161-08-13, modified – Notes to entry have been added.]

3.11
flicker severity
intensity of flicker annoyance 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-hours interval, according to the following expression:

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

Note 1 to entry: For details of P_{st} and P_{lt} , see IEC 61000-4-15.

3.12
frequency deviation
difference between power supply frequency ($f_{H,1}$) and nominal frequency (f_N)

[SOURCE: IEC 60050-614:2016, 614-01-10, modified – The words "system frequency at a given instant and its nominal value" has been changed to "power supply frequency ($f_{H,1}$) and nominal frequency (f_N)".]

3.13
group total harmonic distortion
THDG
$THDG_Y$
ratio of the RMS value of the harmonic groups ($Y_{g,h}$) to the RMS value of the group associated with the fundamental ($Y_{g,1}$):

$$THDG_Y = \sqrt{\sum_{h=2}^{h_{max}} \left(\frac{Y_{g,h}}{Y_{g,1}} \right)^2}$$

Note 1 to entry: The symbol Y is replaced, as required, by the symbol I for currents or by the symbol U for voltages.

[SOURCE: IEC 61000-4-7:2002 and IEC 61000-4-7:2002/AMD1:2008, 3.3.2, modified – Note 2 has been removed.]

3.14
harmonic frequency
$f_{H,h}$
frequency which is an integer multiple of the power supply (fundamental) frequency

[SOURCE: IEC 61000-4-7: 2002 and IEC 61000-4-7:2002/AMD1:2008, 3.2.1, modified – "fundamental frequency of the power system" has been changed to "power supply (fundamental) frequency", and the formula and note have been removed.]

3.15
harmonic order
h
(integer) ratio of a harmonic frequency ($f_{H,h}$) to the power supply frequency ($f_{H,1}$)

[SOURCE: IEC 60050-161:1990, 161-02-19, modified – "the integral number given by the ratio of the frequency of a harmonic to the fundamental frequency" has been changed to "(integer) ratio of a harmonic frequency ($f_{H,h}$) to the power supply frequency ($f_{H,1}$)".]

3.16
harmonic ratio
HR
ratio of individual harmonic order component (U_h or I_h) to the fundamental component (U_1 or I_1)

3.17
mains communicating system
MCS
system using mains power lines to transmit information signals, either on the public electricity distribution network or within installations of network users

[SOURCE: IEC 61000-2-2:2002 and IEC 61000-2-2:2002/AMD1:2017, 3.1.8, modified – The adjective "electrical" has been deleted in the definition.]

3.18
mains communicating voltage
signal superimposed on the supply voltage for the purpose of transmission of information in the public supply network and to network users' premises

Note 1 to entry: Three types of signals in the public supply network can be classified:

– ripple control signals: superimposed sinusoidal voltage signals in the frequency range 110 Hz to 3 000 Hz;
– power-line-carrier signals: superimposed sinusoidal voltage signals in the frequency range 3 kHz to 148,5 kHz;
– mains marking signals: superimposed short time alterations (transients) at selected points of the voltage waveform.

3.19
system operator
network operator
party responsible for safe and reliable operation of a part of the electric power system in a certain area and for connection to other parts of the electric power system

[SOURCE: IEC 60050-617:2009, 617-02-09]

3.20
nominal frequency
f_N
value of frequency used to designate or identify a system

3.21
nominal voltage
U_N
value of voltage used to designate or identify a system

EXAMPLE: Nominal voltage of a system.

[SOURCE: IEC 60050-601:1985, 601-01-21, modified – The symbol has been added and the words "suitable approximate" have been removed from the definition.]

3.22
normal operating conditions
operating conditions of a public electricity supply system typically including all generation variations, load variations and reactive compensation or filter states (e.g. shunt capacitor states), planned outages and planned arrangements during maintenance and construction work, non-ideal operating conditions and normal contingencies under which the considered system has been designed to operate

EXAMPLE Nominal operating conditions of a public electricity supply system

Note 1 to entry: Normal system operating conditions typically exclude exceptional situations such as: conditions arising as a result of a fault or a combination of faults beyond that planned for under the system security standard, unavoidable circumstances (for example: force majeure, exceptional weather conditions and other natural disasters, acts by public authorities, industrial actions), cases where network users significantly exceed their emission limits or do not comply with the connection requirements, and temporary generation or supply arrangements adopted to maintain supply to network users during maintenance or construction work, where otherwise supply would be interrupted.

[SOURCE: IEC TR 61000-3-6:2008, 3.15, modified – The words "of the system or of the disturbing installation" have been replaced by "of a public electricity supply system", "planned" have been added to "arrangements", and "or the disturbing installation" have been deleted; the note to entry has been slightly changed.]

3.23
percentile value
$U_{x\%}$
value such that x percent (x %) of measurements are smaller than or equal to that value, over a given period

3.24
planning level
level of a particular disturbance in a particular environment, adopted as a reference value for the limits to be set for the emissions from the installations in a particular system, in order to co-ordinate those limits with all the limits adopted for equipment and installations intended to be connected to the power supply system

Note 1 to entry: Planning levels are considered internal quality objectives to be specified at a local level by those responsible for planning and operating the power supply system in the relevant area.

[SOURCE: IEC TR 61000-3-6:2008, 3.16]

3.25
point of common coupling
PCC
point in a public power supply network, electrically nearest to a particular load, at which other loads are, or can be, connected

Note 1 to entry: These loads can be either devices, equipment or systems, or distinct network user's installations.

[SOURCE: IEC 60050-161:1990,161-07-15, modified – The words "of a power supply network" have been changed to "in a public power supply network" and "may" has been replaced with "can" in the definition. In Note 1, "customer's" has been changed to "user's" and Note 2 has been deleted.]

3.26
point of supply
supply terminal
point in a distribution or transmission network designated as such and contractually fixed, at which electric energy is exchanged between contractual partners

Note 1 to entry: The point of supply can be different from the boundary between the electricity supply system and the user's own installation or from the metering point.

[SOURCE: IEC 60050-617:2009, 617-04-02, modified – The words "or transmission" have been added in the definition and "may" has been changed to "can" in the note to entry.]

3.27
network user
power network user
party supplying electric power and energy to, or being supplied with electric power and energy from, a transmission system or a distribution system

[SOURCE: IEC 60050-617:2009, 617-02-07]

3.28
power quality
characteristics of the electricity at a given point on an electrical system, evaluated against a set of reference technical parameters

Note 1 to entry: These parameters can, in some cases, relate to the compatibility between electricity supplied on a network and the loads connected to that network.

Note 2 to entry: In the context of this document, power quality refers to the point of supply and focuses on defining the characteristics of the voltage and frequency.

[SOURCE: IEC 60050-617:2009, 617-01-05, modified – The words "electric current, voltage and frequencies" have been replaced with "electricity". In Note 1 to entry, "electric power system" has been replaced with "network" and Note 2 to entry has been added.]

3.29
power quality indices
technical parameters characterizing the quality of electricity, measured at a given point, relevant for the assessment of the quality of the electricity delivered by a network operator

3.30
profile
specification that supplements a standard by limiting options, in order to serve the needs of users in a geographic area or in an application domain

3.31
RMS value of a harmonic component
$Y_{\mathrm{H},h}$
RMS value of one of the components having a harmonic frequency in the analysis of a non-sinusoidal waveform.

Note 1 to entry: For brevity, such a component can be referred to simply as a "harmonic".

Note 2 to entry: The symbol Y is replaced, as required by the symbol I for currents, by the symbol U for voltages.

Note 3 to entry: For more details, see IEC 61000-4-7:2002 and IEC 61000-4-7:2002/AMD1:2008.

[SOURCE: IEC 61000-4-7:2002/AMD1:2008, 3.2.3, modified – The three notes have been replaced.]

3.32
RMS value of a harmonic group
$Y_{g,h}$
square root of the sum of the squares of the RMS value of a harmonic and the spectral components adjacent to it within the time window, thus summing the energy contents of the neighbouring components with that of the harmonic proper

Note 1 to entry: The symbol Y is replaced, as required by the symbol I for currents, by the symbol U for voltages.

Note 2 to entry: For more details, see IEC 61000-4-7:2002/AMD1:2008.

[SOURCE: IEC 61000-4-7:2002 and IEC 61000-4-7:2002/AMD1:2008, 3.2.4, modified – The end of the definition has been deleted and Note 2 to entry added.]

3.33
RMS value of an interharmonic centred subgroup
$Y_{isg,h}$
RMS value of all interharmonic components in the interval between two consecutive harmonic frequencies, excluding frequency components directly adjacent to the harmonic frequencies

Note 1 to entry: The RMS value of the centred subgroup between the harmonic orders h and $h + 1$ is designated as $Y_{isg,h}$; for example, the centred subgroup between h = 5 and h = 6 is designated as $Y_{isg,5.}$

Note 2 to entry: For more details, see IEC 61000-4-7:2002/AMD1:2008.

[SOURCE: IEC 61000-4-7:2002 and IEC 61000-4-7:2002/AMD1:2008, 3.4.4, modified – The words "all spectral components" have been replaced with "all interharmonic components", "excluding spectral components" has been replaced with "excluding frequency components", the reference to the figure has been deleted; the words "For the purpose of this standard" has been removed in Note 1 to entry and Note 2 to entry has been replaced.]

3.34
rapid voltage change
RVC
quick transition (that can last more than several cycles) in RMS voltage occurring between two steady-state conditions, and during which the RMS voltage does not exceed the dip or swell thresholds

Note 1 to entry: For more information, see IEC 61000-4-30.

[SOURCE: IEC 61000-4-30:2021, 3.26, modified – The parenthesis "(that can last more than several cycles)" has been added, the words “dip/swell” have been replace by “dip or swell” and the note to entry replaced.]

3.35
recommended values
value under which, or values within which, the voltage characteristics should remain in view of providing an acceptable quality of the electricity supply

Note 1 to entry: The characteristics of electricity agreed between the network operator and a network user or set by national or regional regulatory authority can be locally optimized.

3.36
reference voltage
value specified as the base on which residual voltage, thresholds and other values are expressed in per unit or percentage terms

Note 1 to entry: A reference voltage can, for example, be set for interruptions, voltage dips and voltage swells measurement and evaluation.

3.37
supply voltage
RMS value of the line-to-line or line-to-neutral voltage at a given time at the point of supply, measured over a given interval

3.38
time aggregation
combination of several sequential values of a given parameter (each determined over identical time intervals) to provide a value for a longer time interval

Note 1 to entry: In this document, 3 s value refers to IEC 61000-4-30 150 or 180-cycle interval aggregation value (150 cycles for 50 Hz nominal or 180 cycles for 60 Hz nominal); 10 min value and 2 h value are also defined in IEC 61000-4-30.

[SOURCE: IEC 61000-4-30:2015, 3.31, modified – Note 1 to entry has been replaced.]

3.39
total harmonic distortion
THD
THD_Y
ratio of the RMS value of the sum of all the harmonic components ($Y_{\mathrm{H},h}$) up to a specified order (h_{max}) to the RMS value of the fundamental component ($Y_{\mathrm{H},1}$):

$$THD_Y = \sqrt{\sum_{h=2}^{h_{\mathrm{max}}} \left(\frac{Y_{\mathrm{H},h}}{Y_{\mathrm{H},1}} \right)^2}$$

Note 1 to entry: The symbol Y is replaced, as required, by the symbol I for currents or by the symbol U for voltages.

Note 2 to entry: For more information, see IEC 61000-4-30:2015, 5.8.1.

3.40
transient overvoltage
voltage surge
transient voltage wave propagating along a line or a circuit and characterized by a rapid increase followed by a slower decrease of the voltage

[SOURCE: IEC 60050-161:1990, 161-08-11, modified – The term "transient overvoltage" has been added as the first preferred term.]

3.41
voltage deviation
difference between supply voltage (U) and nominal voltage (U_{N}), often expressed by relative value

Note 1 to entry: In some circumstances, U_{N} can be replaced by U_{c} by contract or agreement.

3.42
voltage dip
sudden reduction of the voltage at a point in an electrical system followed by voltage recovery after a short period of time, usually from a few cycles to a few seconds

Note 1 to entry: The starting threshold of voltage dip generally is 90 % of reference voltage.

[SOURCE: IEC 60050-161:1990, 161-08-10, modified – The word "from" has been changed to "usually from" and Note 1 to entry has been added.]

3.43
voltage fluctuation
series of voltage changes or a cyclic variation of the supply voltage envelope

Note 1 to entry: For the purpose of this document, the reference voltage is the nominal or declared supply voltage of the supply system.

[SOURCE: IEC 60050-161:1990, 161-08-05, modified – The words "continuous variation of the RMS or peak value of the voltage" have replaced with "a cyclic variation of the supply voltage envelope" and Note 1 to entry has been replaced.]

3.44
voltage short time interruption
disappearance of the supply voltage for a time interval whose duration is between two specified limits

Note 1 to entry: A short time interruption is considered to be a reduction of the supply voltage under the interruption threshold (usually 5 % or 10 % of the reference voltage), with the lower limit of the duration typically a few tenths of a second, and its upper limit typically in the order of 1 min (or, in some cases up to 3 min or 5 min).

[SOURCE: IEC 60050-161:1990, 161-08-20, modified – The term "short interruption" has been replaced with "voltage short time interruption", the domain has been deleted; in Note 1 to entry, some values have been replaced.]

3.45
voltage swell
sudden increase of the voltage at a point in an electrical system followed by voltage recovery after a short period of time, usually from a few cycles to a few seconds

Note 1 to entry: The starting threshold of a voltage swell is generally 110 % of reference voltage.

3.46
voltage unbalance
<polyphase system> condition in which the magnitudes of the phase voltages or the phase angles between consecutive phases are not all equal (fundamental component)

[SOURCE: IEC 60050-161:1990, 161-08-09, modified – The words "RMS values" have been replaced with "magnitudes" and the parenthesis "(fundamental component)" has been added.]

3.47
voltage unbalance factor
< three-phase system> degree of unbalance expressed by the ratio (in per cent) of the RMS values of the negative sequence component (or the zero sequence component) to the positive sequence component of the fundamental component of the voltage

[SOURCE: IEC 60050-614:2016, 614-01-33, modified – Addition of "voltage" to term, deletion of "or the electric current".]