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colour inside

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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Technical specifications are subject to review within three years of publication to decide whether they can be transformed into International Standards.

IEC TS 62749, which is a technical specification, has been prepared by IEC technical committee 8: System aspects of electrical energy supply.

The text of this technical specification is based on the following documents:

DTS	Report on voting
8/1363/DTS	8/1381/RVC

Full information on the voting for the approval of this technical specification can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- transformed into an International standard,
- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

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INTRODUCTION

The description of ELECTRICITY is of fundamental importance within electricity supply systems. In general, its characteristics depend less on its generation than on the way in which it is 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.

There is a need for a common set of power quality 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/regions have been designed in different ways to cater for national/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 level of power quality is not absolute rather it depends on the price that clients are willing to pay for it. Optimizing power quality should be carried out in a cost-effective manner in that if NETWORK USERs expect power quality to be an intrinsic characteristic of the product they also want it at the lowest price.

This is why 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 Technical Specification and PROFILES. Examples of profiles are given in Annex A.

Nowadays, Smart Grid construction and massive deployment of renewable energy sources increase the complexity of power quality management.

ASSESSMENT OF POWER QUALITY – CHARACTERISTICS OF ELECTRICITY SUPPLIED BY PUBLIC NETWORKS

1 Scope

This Technical Specification specifies the expected characteristics of electricity at the SUPPLY TERMINALS of public low, medium and high voltage, 50 Hz or 60 Hz, networks.

NOTE 1 The boundaries between the various voltage levels may be different for different countries/regions. In the context of this TS, the following terms for system voltage are used:

- low voltage (LV) refers to $U_N \leq 1$ kV;
- medium voltage (MV) refers to 1 kV < $U_N \leq 35$ kV;
- high voltage (HV) refers to 35 kV < $U_N \leq 230$ kV;

NOTE 2 Because of existing network structures, in some countries/regions, the boundary between medium and high voltage can be different.

Most of the recommendations for power quality at the SUPPLY TERMINALS are expressed as POWER QUALITY INDICES that describe the manner in which the characteristics of electricity vary. Such variations may appear random in time, with reference to any specific supply terminal, and random in location, with reference to any given instant of time. As such, the POWER QUALITY INDICES are based on the occurrence of the applicable electromagnetic phenomena:

- 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, and
- discontinuous phenomena or events, i.e. sudden and significant deviations from normal or desired wave shape which typically occur due to unpredictable events (e.g. faults) or external causes (e.g. weather conditions).

The power quality indices and the recommended values are intended to be used as technical reference for regulatory purposes (e.g. in NETWORK CODES) or for contracts between network operator and network user (e.g. part of a CONNECTION AGREEMENT).

Power quality requirements combine the obligations of NETWORK OPERATORS with the requirements of equipment or installations on the electromagnetic environment. It is worth noting however, that the requirements of equipment or installations on the electromagnetic environment also include emission aspects that are addressed in other IEC standards (see Clause 2 and Annex F).

NOTE 3 Network operators are in charge of developing and operating the electricity supply system taking into account at the same time:

- provision of adequate conditions for equipment, installations or other networks connected to their network;
- avoidance of unnecessary costs.

NOTE 4 In many countries/regions, requirements concerning the essential characteristics of electricity at supply terminals of public networks are set, or controlled, by National/Regional Regulatory Authorities.

In some cases, additional requirements or differences in requirements can be agreed by terms of a contract (usually a CONNECTION AGREEMENT) between an individual NETWORK USER and the network operator. Such a contract is most likely to arise for network users with relatively large electricity demand, supplied from the MV or HV network, or having power quality sensitive load. It may also arise in sparsely populated or difficult terrain, such as mountain regions, where distribution costs are high. In such an area a network user may be willing to accept a connection, at lower cost, which does not entirely comply with the power quality standards.

NOTE 5 The quality indices and the recommended values appropriately cover the vast majority of locations under acceptable economic conditions, despite the differences in situations, provided that:

- for mass-market products, emission requirements in standards such as IEC 61000-3-2, 3-3, 3-11and/or 3-12 are regularly and appropriately updated to take into account the development of markets and changes in technologies;
- for large installations, emission levels are effectively controlled, e.g. through connection agreement (Annex E lists some methods to improve power quality);
- network operators make use of appropriate methodologies and engineering practices, e.g. based on PLANNING LEVELS and IEC TR 61000-3-6, 3-7, 3-13 and/or 3-14.

This Technical Specification applies to the phenomena listed in Table 1.

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

Continuous phenomena	Discontinuous phenomena – Events
FREQUENCY DEVIATION	SUPPLY INTERRUPTION
SUPPLY VOLTAGE DEVIATION	VOLTAGE DIP
VOLTAGE UNBALANCE	VOLTAGE SWELL
HARMONIC VOLTAGE	TRANSIENT OVERVOLTAGE
INTERHARMONIC VOLTAGE	RAPID VOLTAGE CHANGE
FLICKER （VOLTAGE FLUCTUATION）	
MAINS SIGNALLING VOLTAGES	

NOTE 6 Specification of related measurement methods can be found in IEC 61000-4-30, *EMC – Testing and measurement techniques – Power Quality measurement methods*.

NOTE 7 Specification of the performance of related measuring instruments can be found in IEC 62586, *Power quality measurement in power supply systems*.

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 multiple equipment and/or installations, this Technical Specification is not an EMC publication (see also Annex F).

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60038, *IEC standard voltages*

IEC 60364-4-44, *Low-voltage electrical installations – Part 4-44: Protection for safety – Protection against voltage disturbances and electromagnetic disturbances*

IEC 60364-5-53, *Electrical installations of buildings – Part 5-53: Selection and erection of electrical equipment – Isolation, switching and control*

IEC 61000-2-2, *Electromagnetic compatibility (EMC) – Part 2-2: Environment – Compatibility levels for low-frequency conducted disturbances and signalling in public low-voltage power supply systems*

IEC TR 61000-2-8, *Electromagnetic compatibility (EMC) – Part 1-8: Environment – Voltage dips and short interruptions on public electric power supply systems with statistical measurement results*

IEC 61000-2-12, *Electromagnetic compatibility (EMC) – Part 2-12: Environment – Compatibility levels for low-frequency conducted disturbances and signalling in public medium-voltage power supply systems*

IEC TR 61000-2-14, *Electromagnetic compatibility (EMC) – Part 2-14: Environment – Overvoltages on public electricity distribution networks*

IEC 61000-3-2, *Electromagnetic compatibility (EMC) – Part 3-2: Limits – Limits for harmonic current emissions (equipment input current ≤ 16 A per phase)*

IEC 61000-3-3, *Electromagnetic compatibility (EMC) – Part 3-3: Limits – Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current ≤ 16 A per phase and not subject to conditional connection*

IEC TR 61000-3-6, *Electromagnetic compatibility (EMC) – Part 3-6: Limits – Assessment of emission limits for the connection of distorting installations to MV, HV and EHV power systems*

IEC TR 61000-3-7, *Electromagnetic compatibility (EMC) – Part 3-7: Limits – Assessment of emission limits for the connection of fluctuating load installations to MV, HV and EHV power systems*

IEC 61000-3-11, *Electromagnetic compatibility (EMC) – Part 3-11: Limits – Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems – Equipment with rated current ≤ 75 A and subject to conditional connection*

IEC 61000-3-12, *Electromagnetic compatibility (EMC) – Part 3-12: Limits – Limits for harmonic currents produced by equipment connected to public low-voltage systems with input current >16 A and ≤ 75 A per phase*

IEC TR 61000-3-13, *Electromagnetic compatibility (EMC) – Part 3-13: Limits – Assessment of emission limits for the connection of unbalanced installations to MV, HV and EHV power systems*

IEC TR 61000-3-14, *Electromagnetic compatibility (EMC) – Part 3-14: Limits – Assessment of emission limits for the connection of disturbing installations to LV power systems*

IEC 61000-4-7:2009, *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 61000-4-15, *Electromagnetic compatibility (EMC) – Part 4-15: Testing and measurement techniques – Flickermeter – Functional and design specifications*

IEC 61000-4-30:2008, *Electromagnetic compatibility (EMC) – Part 4-30: Testing and measurement techniques – Power quality measurement methods*

IEC 62586-1, *Power quality measurement in power supply systems – Part 1: Power quality instruments (PQI)*

IEC 62586-2, *Power quality measurement in power supply systems – Part 2: Functional tests and uncertainty requirements*

3 Terms and definitions

For the purpose of this Technical Specification, the following terms and definitions apply.

NOTE Terms are listed in alphabetical order.

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

Note 1 to entry: For example: grid code, distribution code.

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

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*$_c$** (abbreviation)
supply voltage U_c 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

[SOURCE: IEC 60050-121:1998, 121-11-76]

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

3.5
electromagnetic compatibility
ability of an equipment or system to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbances to anything in that environment

[SOURCE: IEC 60050-161:1990, 161-01-07]

3.6
(electromagnetic) compatibility level
specified electromagnetic disturbance level used as a reference level for coordination 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.

3.7
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 behavior.

[SOURCE: IEC 60050-161:1990, 161-08-13, modified (addition of Notes to entry)]

3.8
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 Pst-values over a two hour 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 Pst and Plt, see IEC 61000-4-15.

3.9
frequency deviation
difference between power supply frequency ($f_{H,1}$) and nominal frequency (f_N)

3.10
group total harmonic distortion
THDG (abbreviation)
***THDG*$_Y$**(symbol)

ratio of the r.m.s. value of the harmonic groups ($Y_{g,h}$) to the r.m.s. 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 61000-4-7:2009, 3.3]

3.11
harmonic frequency
***f*$_{H,h}$** (abbreviation)
frequency which is an integer multiple of the power supply (fundamental) frequency

[SOURCE: IEC 61000-4-7:2009, 3.2.1, modified (removal of formula and Note to entry)]

3.12
harmonic order
h (abbreviation)
(integer) ratio of a harmonic frequency ($f_{H,h}$) to the power supply frequency ($f_{H,1}$)

3.13
harmonic ratio
HR (abbreviation)
ratio of individual harmonic order component (U_h or I_h) to the fundamental component (U_1 or I_1)

3.14
mains signalling 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.

3.15
network operator
system 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]

3.16
nominal frequency
***f*$_N$** (abbreviation)
value of frequency used to designate or identify a system