

TECHNICAL SPECIFICATION



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



THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2015 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester. If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

IEC Central Office
3, rue de Varembe
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00
info@iec.ch
www.iec.ch

About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigenda or an amendment might have been published.

IEC Catalogue - webstore.iec.ch/catalogue

The stand-alone application for consulting the entire bibliographical information on IEC International Standards, Technical Specifications, Technical Reports and other documents. Available for PC, Mac OS, Android Tablets and iPad.

IEC publications search - www.iec.ch/searchpub

The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee,...). It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished

Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and also once a month by email.

Electropedia - www.electropedia.org

The world's leading online dictionary of electronic and electrical terms containing more than 30 000 terms and definitions in English and French, with equivalent terms in 15 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

IEC Glossary - std.iec.ch/glossary

More than 60 000 electrotechnical terminology entries in English and French extracted from the Terms and Definitions clause of IEC publications issued since 2002. Some entries have been collected from earlier publications of IEC TC 37, 77, 86 and CISPR.

IEC Customer Service Centre - webstore.iec.ch/csc

If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: csc@iec.ch.

TECHNICAL SPECIFICATION



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

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 17.220.99

ISBN 978-2-8322-2547-9

Warning! Make sure that you obtained this publication from an authorized distributor.

CONTENTS

FOREWORD.....	4
INTRODUCTION.....	6
1 Scope.....	7
2 Normative references	8
3 Terms and definitions	9
4 Recommended values for power quality indices.....	16
4.1 General.....	16
4.2 Frequency deviation.....	16
4.3 Supply voltage deviation	16
4.3.1 General	16
4.3.2 Low voltage systems	16
4.3.3 Medium voltage systems.....	17
4.3.4 High voltage systems.....	17
4.4 Voltage unbalance	18
4.5 Flicker.....	18
4.6 Harmonic and interharmonic voltage	18
4.6.1 General	18
4.6.2 Low voltage systems	18
4.6.3 Medium voltage systems.....	19
4.6.4 High voltage systems.....	20
4.7 Voltage dip	21
4.8 Voltage swell	22
4.9 Voltage interruption.....	22
4.10 Mains signalling voltage.....	22
4.11 Rapid voltage change	23
4.12 Transient overvoltage	23
4.12.1 Low voltage systems	23
4.12.2 Medium and High voltage systems.....	24
5 Objectives and methods for power quality assessment	24
5.1 General.....	24
5.2 Site power quality assessment.....	24
5.2.1 General	24
5.2.2 For continuous phenomena.....	25
5.2.3 For discontinuous phenomena (single event)	26
5.3 System aspect power quality assessment	27
5.3.1 General	27
5.3.2 For continuous phenomena.....	27
5.3.3 For discontinuous phenomena (events)	27
Annex A (informative) Examples of PROFILES for Power Quality Specification.....	30
A.1 LV public distribution in European countries.....	30
A.2 LV, MV and HV power supply system in China	31
A.3 Example of a transmission system in Canada	32
A.4 Examples of Profiles in Australia.....	33
Annex B (informative) Example on System Aspect Continuous Disturbance Evaluation.....	34
Annex C (informative) Main Impact of Poor Power Quality.....	35

C.1	Harmonic distortion	35
C.2	Voltage unbalance	35
C.3	Voltage deviation	36
C.4	Frequency deviation	36
C.5	Voltage fluctuation	36
C.6	Flicker	36
C.7	Voltage dip (or Voltage sag)	36
C.8	Transient overvoltages	36
Annex D (informative) Power Quality Issues Related to Distributed Generation and Micro-grids		37
D.1	Voltage deviation	37
D.2	Harmonics	37
D.3	DG magnetic bias (DC current injection)	37
D.4	Voltage fluctuation and flicker	37
D.5	High frequency conducted disturbances	38
Annex E (informative) Methods to Maintain and Improve Power Quality		39
E.1	Voltage deviation	39
E.2	Harmonics	39
E.3	Flicker	40
E.4	Unbalance	40
E.5	Voltage dip/swell/short time interruption	40
Annex F (informative) Relation between Power quality and EMC		41
Bibliography		43
Figure 1 – Signal voltages recommended values in percent of U_N used in public LV networks (or U_C in public MV networks)		23
Figure 2 – An example for illustrating voltage THD assessment result trends		26
Figure 3 – An example showing information of single event assessment		27
Figure F.1 – Application points in a LV system (example)		42
Figure F.2 – Relation between disturbance levels (Schematic significance only)		42
Table 1 – Classification of electromagnetic phenomena addressed by power quality indices		8
Table 2 – Flicker severity P_{It} recommended values		18
Table 3 – Recommended values of individual harmonic voltages at the low voltage supply terminals for orders up to 50 given in percent of the fundamental voltage U_1		19
Table 4 – Recommended values of individual harmonic voltages at the medium voltage supply terminals for orders up to 50 given in percent of the fundamental voltage U_1		20
Table 5 – Indicative values of individual harmonic voltages at the high voltage supply terminals given in percent of the fundamental voltage U_1		21
Table 6 – Site power quality assessment methods		25
Table 7 – Example of single event assessment		27
Table 8 – List of individual events measured at a single monitoring site		28
Table 9 – SARFI-X indices coming out of Table 8		28
Table 10 – Magnitude – duration table format		29
Table B.1 – Listing of System Power Quality Evaluation		34

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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

FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

The main task of IEC technical committees is to prepare International Standards. In exceptional circumstances, a technical committee may propose the publication of a technical specification when

- the required support cannot be obtained for the publication of an International Standard, despite repeated efforts, or
- the subject is still under technical development or where, for any other reason, there is the future but no immediate possibility of an agreement on an International Standard.

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.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

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

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, 3-11 and/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]