IEC 61400-21-1

Edition 1.0 2019-05

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

Wind energy generation systems –
Part 21-1: Measurement and assessment of electrical characteristics – Wind turbines

Systèmes de génération d'énergie éolienne –
Partie 21-1: Mesurage et évaluation des caractéristiques électriques – Éoliennes

IEC 61400-21-1:2019-05(en-fr)

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

Tel.: +41 22 919 02 11
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 corrigendum or an amendment might have been published.

IEC publications search - webstore.iec.ch/advsearchform
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 It also gives information on projects, replaced and withdrawn publications.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 once a month by email.

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: sales@iec.ch.

Electropedia - www.electropedia.org
The world's leading online dictionary on electrotechnology, containing more than 22 000 terminological entries in English and French, with equivalent terms in 16 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

IEC Glossary - std.iec.ch/glossary
67 000 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.

A propos de l'IEC
La Commission Electrotechnique Internationale (IEC) est la première organisation mondiale qui élabore et publie des Normes internationales pour tout ce qui a trait à l'électricité, à l'électronique et aux technologies apparentées.

A propos des publications IEC
Le contenu technique des publications IEC est constamment revu. Veuillez vous assurer que vous possédez l'édition la plus récente, un corrigendum ou amendement peut avoir été publié.

Recherche de publications IEC - webstore.iec.ch/advsearchform
La recherche avancée permet de trouver des publications IEC en utilisant différents critères (numéro de référence, texte, comité d'études,…). Elle donne aussi des informations sur les projets et les publications remplacées ou retirées.

IEC Just Published - webstore.iec.ch/justpublished
Restez informé sur les nouvelles publications IEC. Just Published détaille les nouvelles publications parues. Disponible en ligne et une fois par mois par email.

Service Clients - webstore.iec.ch/csc
Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions contactez-nous: sales@iec.ch.

Electropedia - www.electropedia.org
Le premier dictionnaire d'électrotechnologie en ligne au monde, avec plus de 22 000 articles terminologiques en anglais et en français, ainsi que les termes équivalents dans 16 langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International (IEV) en ligne.

Glossaire IEC - std.iec.ch/glossary
67 000 entrées terminologiques électrotechniques, en anglais et en français, extraites des articles Termes et Définitions des publications IEC parues depuis 2002. Plus certaines entrées antérieures extraites des publications des CE 37, 77, 86 et CISPR de l'IEC.

IEC 61400-21-1

Edition 1.0 2019-05

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

Wind energy generation systems – Part 21-1: Measurement and assessment of electrical characteristics – Wind turbines

Systèmes de génération d'énergie éolienne – Partie 21-1: Mesurage et évaluation des caractéristiques électriques – Éoliennes

INTERNATIONAL ELECTROTECHNICAL COMMISSION

COMMISSION ELECTROTECHNIQUE INTERNATIONALE

ICS 27.180 ISBN 978-2-8322-6761-5

Warning! Make sure that you obtained this publication from an authorized distributor.
Attention! Veuillez vous assurer que vous avez obtenu cette publication via un distributeur agréé.

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

WIND ENERGY GENERATION SYSTEMS –

Part 21-1: Measurement and assessment of electrical characteristics – Wind turbines

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.

International Standard IEC 61400-21-1 has been prepared by IEC technical committee 88: Wind energy generation systems.

This first edition cancels and replaces the second edition of 61400-21 published in 2008. This edition constitutes a technical revision.

This edition includes the following new items with respect to 61400-21:

a) frequency control measurement;
b) updated reactive power control and capability measurement, including voltage and cos φ control;
c) inertia control response measurement;
d) overvoltage ride through test procedure;
e) updated undervoltage ride through test procedure based on Wind Turbine capability;

f) new methods for the harmonic assessment.

Parts of the assessments related to the wind power plant evaluation are moved to Annex E, as they will be replaced by IEC 61400-21-2, *Measurement and assessment of electrical characteristics – Wind power plants*.

The text of this International Standard is based on the following documents:

FDIS	Report on voting
88/711/FDIS	88/716/RVD

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

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

A list of all parts in the IEC 61400 series, published under the general title *Wind energy generation systems*, can be found on the IEC website.

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

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

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

This part of IEC 61400 provides a uniform methodology that will ensure consistency and accuracy in reporting, testing and assessment of electrical characteristics of grid connected wind turbines (WTs). The electrical characteristics include wind turbine specifications and capabilities, voltage quality (emissions of flicker and harmonics), under- and overvoltage ride-through response, active power control, frequency control, voltage control, and reactive power control, grid protection and reconnection time.

This part of IEC 61400 has been prepared with the anticipation that it would be applied by:

- the WT manufacturer, striving to meet well-defined electrical characteristics;
- the WT purchaser, in specifying such electrical characteristics;
- the WT operator, who may be required to verify that stated, or required electrical characteristics are met;
- the WT planner or regulator, who has to be able to accurately and fairly determine the impact of a WT on the voltage quality to ensure that the installation is designed so that voltage quality requirements are respected;
- the WT certification authority or testing organization, in evaluating the electrical characteristics of the wind turbine type;
- the planner or regulator of the electric network, who has to be able to determine the grid connection required for a WT.

This part of IEC 61400 provides recommendations for preparing the measurements and assessment of electrical characteristics of grid connected WTs. This document will benefit those parties involved in the manufacture, installation planning, obtaining of permission, operation, usage, testing and regulation of WTs. The measurement and analysis techniques, recommended in this document, should be applied by all parties to ensure that the continuing development and operation of WTs are carried out in an atmosphere of consistent and accurate communication.

This part of IEC 61400 presents measurement and analysis procedures expected to provide consistent results that can be replicated by others. Any selection of tests can be done and reported separately.

WIND ENERGY GENERATION SYSTEMS –

Part 21-1: Measurement and assessment of electrical characteristics – Wind turbines

1 Scope

This part of IEC 61400 includes:

- definition and specification of the quantities to be determined for characterizing the electrical characteristics of a grid-connected wind turbine;
- measurement procedures for quantifying the electrical characteristics;
- procedures for assessing compliance with electrical connection requirements, including estimation of the power quality expected from the wind turbine type when deployed at a specific site.

The measurement procedures are valid for single wind turbines with a three-phase grid connection. The measurement procedures are valid for any size of wind turbine, though this part of IEC 61400 only requires wind turbine types intended for connection to an electricity supply network to be tested and characterized as specified in this part of IEC 61400.

The measured characteristics are valid for the specific configuration and operational mode of the assessed wind turbine product platform. If a measured property is based on control parameters and the behavior of the wind turbine can be changed for this property, it is stated in the test report. Example: Grid protection, where the disconnect level is based on a parameter and the test only verifies the proper functioning of the protection, not the specific level.

The measurement procedures are designed to be as non-site-specific as possible, so that electrical characteristics measured at for example a test site can be considered representative for other sites.

This document is for the testing of wind turbines; all procedures, measurements and tests related to wind power plants are covered by IEC 61400-21-2.

The procedures for assessing electrical characteristics are valid for wind turbines with the connection to the PCC in power systems with stable grid frequency.

NOTE

For the purposes of this document, the following terms for system voltage apply:

– 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 < $U_n \leq 220$ kV;

– Extra high voltage (EHV) refers to $U_n > 220$ kV.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 61000-3-2:2014, *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 – Limits 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 installations to MV, HV and EHV power systems*

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

IEC 61000-4-7:2002, *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 61000-4-7:2002/AMD1:2008

IEC 61000-4-15:2010, *Electromagnetic compatibility (EMC) – Part 4-15: Testing and measurement techniques – Flickermeter – Functional and design specifications*

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

IEC TR 61869-103:2012, *Instrument transformers – The use of instrument transformers for power quality measurement*

IEC 62008, *Performance characteristics and calibration methods for digital data acquisition systems and relevant software*

3 Terms and definitions

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

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

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1
continuous operation
normal operation of the wind turbine excluding switching operations

3.2
cut-in wind speed
lowest wind speed at hub height at which the wind turbine starts to produce power

[SOURCE: IEC 60050-415:1999, 415-03-05]

3.3
disconnection time
time duration from exceeding a predefined disconnection level until the physical disconnection of the wind turbine from the grid

3.4
flicker coefficient for continuous operation
$c(\psi_k)$
normalized measure of the flicker emission during continuous operation of the wind turbine

$$c(\psi_k) = P_{st,fic} \times \frac{S_{k,fic}}{S_n}$$

where

$P_{st,fic}$ is the short-term flicker severity from the wind turbine on the fictitious grid;

S_n is the nominal apparent power of the wind turbine;

$S_{k,fic}$ is the short-circuit apparent power of the fictitious grid

3.5
flicker step factor
$k_f(\psi_k)$
normalized measure of the flicker emission due to a single switching operation of the wind turbine

$$k_f(\psi_k) = \frac{1}{130} \times \frac{S_{k,fic}}{S_n} \times P_{st,fic} \times T_p^{0,31}$$

where

T_p is the measurement period in seconds, long enough to ensure that the transient of the switching operation has abated, though limited to exclude possible power fluctuations due to turbulence;

$P_{st,fic}$ is the short-term flicker severity from the wind turbine on the fictitious grid;

S_n is the nominal apparent power of the wind turbine;

$S_{k,fic}$ is the short-circuit apparent power of the fictitious grid

Note 1 to entry: The short-term flicker severity $P_{st,fic}$ is here evaluated over the time period T_p.

3.6
maximum measured power
highest measured value of active power (with a specified averaging time) that is observed during continuous operation of the wind turbine

3.7
network impedance phase angle
ψ_k
phase angle of network short-circuit impedance

$$\psi_k = \arctan(X_k / R_k)$$

where

X_k is the network short-circuit reactance;

R_k is the network short-circuit resistance

3.8
normal operation
fault free operation according to the description in the wind turbine manual

3.9
operational mode
operation according to control setting, for example voltage control mode, frequency control mode, reactive power control mode, active power control mode, etc.

3.10
output power
electric active power delivered by the wind turbine at its terminals

[SOURCE: IEC 60050-415:1999, 415-04-02, modified – "at any time by a wind turbine generator system" has been replaced by "by the wind turbine at its terminals"]

3.11
point of common coupling
PCC
point of a power supply network, electrically nearest to a particular load, at which other loads may be connected

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

Note 2 to entry: In some applications, the term "point of common coupling" is restricted to public networks.

Note 3 to entry: This note applies to the French language only.

[SOURCE: IEC 60050-161:1990, 161-07-15, modified – "are, or may be" has been replaced by "may be".]

3.12
power collection system
electrical system that collects the power from a wind turbine and feeds it into an electrical supply network

[SOURCE: IEC 60050-415:1999, 415-04-06, modified – "generator system" has been deleted and "a network step-up transformer or electrical loads" has been replaced by " an electrical supply network".]

3.13
nominal apparent power
S_n
apparent power from the wind turbine while operating at nominal current and nominal voltage and frequency

$$S_n = \sqrt{3} U_n I_n \text{ at } Q = 0$$

where

U_n is the nominal voltage;

I_n is the nominal current

3.14
nominal current
nominal value I_n of wind turbine current, which are calculated from nominal active power P_n and nominal voltage U_n according to $I_n = \frac{P_n}{\sqrt{3} U_n}$

3.15
nominal active power
nominal value of wind turbine active power, which is stated by the manufacturer and is used as a per-unit base for all powers (active, reactive, apparent)

3.16
Q capability
reactive power capability of a wind turbine, which is measured from the capability curve or by a site-specific test or defined by the manufacturer

3.17
nominal wind speed
wind speed at which a wind turbine's nominal active power is achieved

[SOURCE: IEC 60050-415:1999, 415-03-04, modified – the term defined "rated wind speed" has been changed to "nominal wind speed".]

3.18
standstill
condition of a wind turbine that is stopped

[SOURCE: IEC 60050-415:1999, 415-01-15, modified – "wind turbine generator system" has been changed to "wind turbine"]

3.19
start-up
transitional state of a wind turbine between standstill and power production

3.20
short-circuit ratio
SCR
ratio of the short circuit apparent power S_k to the nominal power S_n

$$SCR = \frac{S_k}{S_n}$$

3.21
switching operation
start-up or shutdown of the wind turbine, or switching between generators in the wind turbine

3.22
turbulence intensity
ratio of the wind speed standard deviation to the mean wind speed, determined from the same set of measured data samples of wind speed, and taken over a specified period of time

[SOURCE: IEC 60050-415:1999, 415-03-25]

3.23
voltage change factor
$k_u(\psi_k)$
normalized measure of the voltage change due to a switching operation of the wind turbine:

$$k_u(\psi_k) = \sqrt{3} \times \frac{U_{fic,max} - U_{fic,min}}{U_n} \times \frac{S_{k,fic}}{S_n}$$

where

$U_{fic,min}$ and $U_{fic,max}$	are the minimum and maximum one period RMS value of the phase-to-neutral voltage on the fictitious grid during the switching operation;
U_n	is the nominal phase-to-phase voltage;
S_n	is the nominal apparent power of the wind turbine;
$S_{k,fic}$	is the short-circuit apparent power of the fictitious grid.

Note 1 to entry: The voltage change factor k_u is similar to k_i being the ratio between the maximum inrush current and the nominal current, though k_u is a function of the network impedance phase angle. The highest value of k_u will be numerically close to k_i.

3.24
wind turbine
WT
system that converts kinetic wind energy into electric energy

Note 1 to entry: This note applies to the French language only.

3.25
wind turbine terminals
point that is part of the WT and identified by the WT manufacturer as a point at which the WT may be connected to the power collection system

3.26
voltage dip
limited duration non-periodic sudden decrease of the power supply network's voltage magnitude and associated change of its phase

Note 1 to entry: In some articles, publications, etc. the expression "voltage sags" is used for the same event.

3.27
voltage swell
limited duration non-periodic sudden increase of the power supply network's voltage magnitude above its nominal value and associated change of the phase of the voltage

3.28
fault ride through
FRT
ability of a wind turbine or wind power plant to stay connected during faults in the grid

Note 1 to entry: This note applies to the French language only.

3.29
undervoltage ride through
UVRT
ability of a wind turbine or wind power plant to stay connected during voltage dips

Note 1 to entry: In some publications, the expression "low voltage ride through (LVRT)", is used for the same event.

Note 2 to entry: This note applies to the French language only.

3.30
overvoltage ride through
OVRT
ability of a wind turbine or wind power plant to stay connected during voltage swells

Note 1 to entry: In some publications, the expression "high voltage ride through (HVRT)", is used for the same event.

Note 2 to entry: This note applies to the French language only.

3.31
phasor
representation of a sinusoidal quantity by a complex quantity whose argument is equal to the initial phase and whose modulus is equal to the root-mean-square value or to the amplitude

Note 1 to entry: For a quantity $a(t) = A\sqrt{2}\cos(\omega t + \theta_0) = A_m \cos(\omega t + \theta_0)$ the phasor is either $A e^{j\theta_0}$ or $A_m e^{j\theta_0}$.

Note 2 to entry: A phasor can also be represented graphically.

[SOURCE: IEC 60050-131:2002, 131-11-26, modified – "integral" has been deleted, "or to the amplitude" has been added, and the first note has been modified]

3.32
positive sequence component of the fundamental
for a three-phase system with phases L1, L2 and L3, the symmetrical sinusoidal three-phase set of voltages or currents having positive frequency equal to the fundamental frequency. The positive sequence component is defined by the following complex mathematical expression:

$$\underline{X}_1 = \frac{1}{3}\left(\underline{X}_{L1} + \underline{a}\underline{X}_{L2} + \underline{a}^2 \underline{X}_{L3}\right)$$

where $\underline{a} = e^{j2\pi/3}$ is the 120-degree operator, and $\underline{X}_{L1}$, $\underline{X}_{L2}$ and $\underline{X}_{L3}$ are the complex expressions of the fundamental frequency phase quantities concerned, that is, current or voltage phasors

Note 1 to entry: In a balanced harmonic-free system, only positive sequence component of the fundamental exists. For example, if phase voltage phasors are symmetrical $\underline{U}_{L1} = Ue^{j\theta}$, $\underline{U}_{L2} = Ue^{j(\theta+4\pi/3)}$ and $\underline{U}_{L3} = Ue^{j(\theta+2\pi/3)}$ then $\underline{U}_1 = (Ue^{j\theta} + e^{j2\pi/3}\, Ue^{j(\theta+4\pi/3)} + e^{j4\pi/3}\, Ue^{j(\theta+2\pi/3)})/3 = (Ue^{j\theta} + Ue^{j\theta} + Ue^{j\theta})/3 = Ue^{j\theta}$.

[SOURCE: IEC 60050-448:1995, 448-11-27, modified – the term and the definition have been modified and Note 1 to entry has been added.]

3.33
negative sequence component of the fundamental
for a three-phase system with phases L_1, L_2 and L_3, the symmetrical sinusoidal three-phase set of voltages or currents having negative frequency the absolute value of which is equal to the fundamental frequency

Note 1 to entry: The negative sequence component is defined by the following complex mathematical expression:

$$\underline{X}_2 = \frac{1}{3}\left(\underline{X}_{L_1} + \underline{a}^2 \underline{X}_{L_2} + \underline{a}\underline{X}_{L_3}\right)$$

where a = $e^{j2\pi/3}$ is the 120-degree operator, and $\underline{X}_{L1}$, $\underline{X}_{L2}$ and $\underline{X}_{L3}$ are the complex expressions of the fundamental frequency phase quantities concerned, that is, current or voltage phasors.

Note 2 to entry: Negative sequence voltage or current components may be significant only when the voltages or currents, respectively, are unbalanced. For example, if phase voltage phasors are symmetrical $\underline{U}_{L1} = Ue^{j\theta}$, $\underline{U}_{L2} = Ue^{j(\theta+4\pi/3)}$ and $\underline{U}_{L3} = Ue^{j(\theta+2\pi/3)}$ then $\underline{U}_2 = (Ue^{j\theta} + e^{j4\pi/3}\, Ue^{j(\theta+4\pi/3)} + e^{j2\pi/3}\, Ue^{j(\theta+2\pi/3)})/3 = Ue^{j\theta}\,(1 + e^{j2\pi/3} + e^{j4\pi/3})/3 = 0$

[SOURCE: IEC 60050-448:1995, 448-11-28, modified – The term and the definition have been modified and two notes to entry added.]

3.34
zero-sequence component of the fundamental
for a three-phase system with phases L1, L2 and L3, the in-phase sinusoidal voltage or current component having the fundamental frequency and equal amplitude in each of the phases

Note 1 to entry: The zero-sequence component is defined by the following complex mathematical expression:

$$\underline{X}_0 = \frac{1}{3}\left(\underline{X}_{L1} + \underline{X}_{L2} + \underline{X}_{L3}\right)$$

where $\underline{X}_{L1}$, $\underline{X}_{L2}$ and $\underline{X}_{L3}$ are the complex expressions of the fundamental frequency phase quantities concerned, that is, current or voltage phasors

[SOURCE: IEC 60050-448:1995, 448-11-29, modified – the term and the definition have been modified and the note to entry added.]

3.35
unbalance factor
in a three-phase system, the degree of unbalance expressed by the ratio $\left|\underline{X}_2/\underline{X}_1\right|$ (in percent) between the values of the negative sequence component $\underline{X}_2$ and the positive sequence component $\underline{X}_1$ of voltage or current

[SOURCE: IEC 60050-614:2016, 614-01-33, modified – The symbols have been added.]

3.36
control interface
point that is part of the WT and identified by the WT supplier as a point at which the WT may be connected to the power plant control system

3.37
wind power plant
power station comprising one or more wind turbines, auxiliary equipment and plant control

3.38
assessor
body accredited to do the assessment

3.39
time-series
record consisting of the numerical values of a time varying signal’s equidistant samples

Note 1 to entry: Samples may represent a measured signal or data processed from the measured values.

3.40
short-circuit apparent power
S_k
product of the current in the short circuit at a point of a system and a conventional voltage, generally the operating voltage

3.41
percentile
value of a variable below which a certain percent of observations fall

3.42
synthetic inertia
wind turbine or wind power plant active power production as a function of time after a sudden change in the grid frequency

Note 1 to entry: The expression "synthetic inertia" are in some publications also defined as "virtual inertia", "fast frequency response", "inertia control". In this document, we use the term "synthetic inertia" for this functionality.

3.43
static error
deviation between the obtained values compared to a requested reference value

3.44
response time
elapsed time from the start of a step change or start of event until the observed value first time enters the predefined tolerance band of the target value

Note 1 to entry: See Figure 1.

3.45
settling time
elapsed time from the start of a step change event until the observed value continuously stays within the predefined tolerance band of the target value

Note 1 to entry: See Figure 1.

3.46
rise time
time from when the observed value reaches 10 % of the step change until the observed value reaches 90 % of the step change

Note 1 to entry: See Figure 1.

3.47
overshoot
difference between the maximum value of the response and the steady-state final value

Note 1 to entry: See Figure 1.

3.48
reaction time
elapsed time from test command issued until the change in amplitude reaches 10 % of the measured output variable of the step height

Note 1 to entry: See Figure 1.

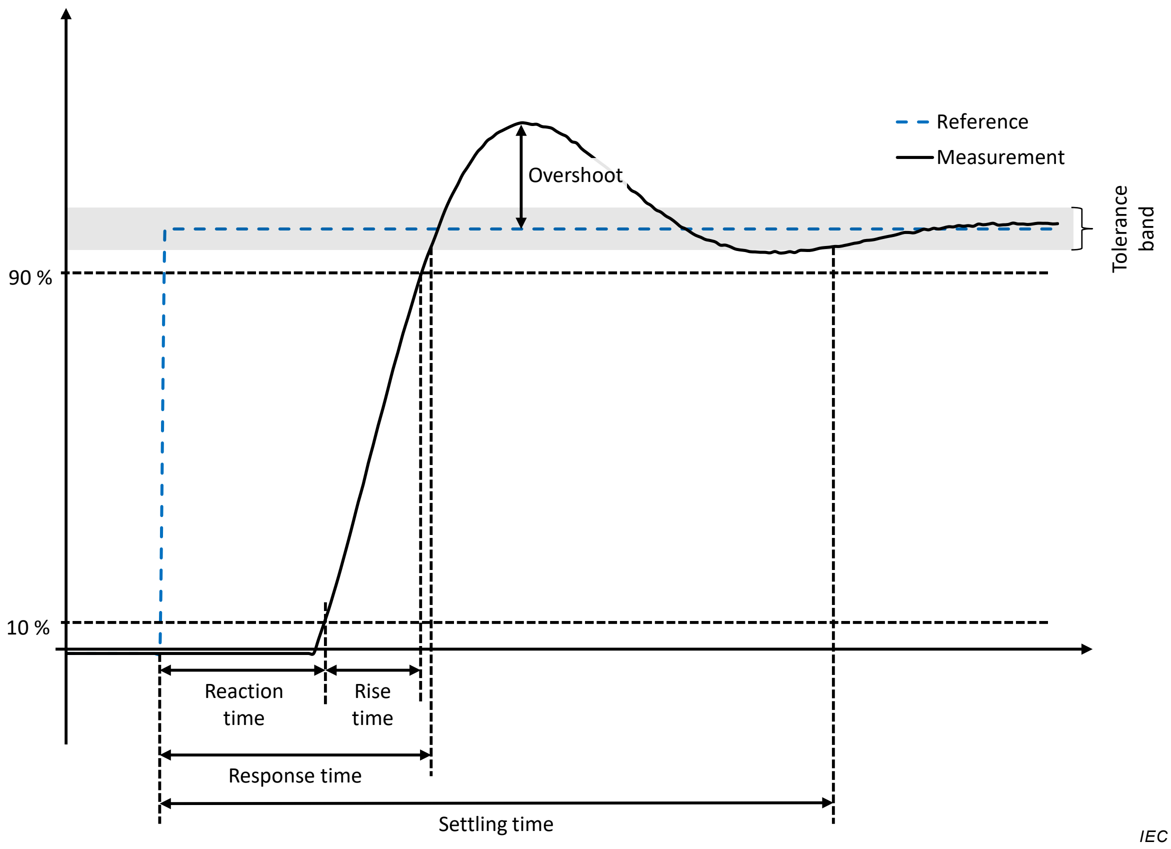

Figure 1 – Example of step response

3.49
ramp-down time
time during which the measured value decreases from 90 % to 10 % of the target value

3.50
recovery time
time from end of the event after which the measured value is continuously within the predefined tolerance band around the start value before the event

3.51
steady state
status of the system obtained when the settling time has expired

3.52
tolerance band
acceptable deviation range of the measured signal from the defined target value

Note 1 to entry: The steady-state target value is usually defined to be equal to the observed signal's reference value or the value towards which the observed signal is converging after the event.

Note 2 to entry: Default tolerance band is defined to be ±10 % of the nominal value if nothing else is stated.

3.53
start of event
time instant where the stimulus value deviates for the first time outside its defined stimulus tolerance band

Note 1 to entry: Stimulus may be a reference signal or a disturbance.

Note 2 to entry: Default stimulus tolerance band is defined to be ±10 % of the stimulus increment and centred on the value the stimulus had before the event.

3.54
wind turbine product platform
turbines sharing the same mechanical platform, electrical system and main drive train components

Note 1 to entry: These turbines are part of the same turbine platform (family) and the differences are typical of the IEC 61400-1 wind classes; they are designed for with the corresponding rotor diameter and nominal power.

Note 2 to entry: Other examples of turbines from the same platform are e.g. wind turbines with different wind turbine transformer primary side voltage ratings, wind turbines with different rotor diameters, etc. See also Annex F.

3.55
component test
test on a single component, where all necessary functions and performance for the test are available in the component and are not dependent on other components/systems (e.g. the protection device, if this an independent unit)

Note 1 to entry: Test done on component level is valid for all turbine variants, where the component is used.

3.56
sub-system
portion of a system that fulfils a specific function, consisting of several components/elements, which are directly related to each other and are directly interacting for the defined function

3.57
sub-system test
test on a sub-system, where all necessary functions and performance for the test are available in the sub-system and are not dependent on other components or systems

Note 1 to entry: Test done on a sub-system is valid for all turbine variants, where the sub-system is used.

3.58
available active power
predicted instantaneous active power from the turbine, either based on the power curve and measured wind speed or as an output from the turbine controller, where more parameters are taken into the calculation

3.59
power factor
under periodic conditions, ratio of the absolute value of the active power P to the apparent power S:

$$PF = \frac{P}{S} \quad PF = \frac{|P|}{S}$$

Note 1 to entry: Under sinusoidal conditions, the power factor is the absolute value of the active factor.

[SOURCE: IEC 60050-131:2002, 131-11-46]

3.60
ramp rate
gradient of ramp during a given period

3.61
reference value
target value that a control system aims to reach

3.62
active power bin
consecutive, non-overlapping intervals of WT active power measured at WT terminals

Note 1 to entry: The bins (intervals) are equal size from 0 %, 10 %, 20 %, … , 100 % of P_n. 0 %, 10 %, 20 %, … , 100 % are the bin midpoints.

3.63
fictitious grid
representation of an ideal phase-to-neutral voltage source with the instantaneous value $u_0(t)$, in series with a defined grid resistance R and grid inductance L

Note 1 to entry: The fictitious grid is used for the normalization of flicker measurements.

3.64
field measurement
measurements performed on a wind turbine or wind power plant installation on a given site

3.65
field test
tests to validate and measure the performance of a wind turbine or wind power plant installation on a given site

3.66
wind speed bin
groups of 10- or 1-minute average measurements into bins based on the average wind speed