

# INTERNATIONAL STANDARD

# NORME INTERNATIONALE



**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**



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

Tel.: +41 22 919 02 11  
[info@iec.ch](mailto:info@iec.ch)  
[www.iec.ch](http://www.iec.ch)

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**WIND ENERGY GENERATION SYSTEMS –****Part 21-1: Measurement and assessment of electrical characteristics –  
Wind turbines**

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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  $\cos \varphi$  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- withdrawn,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  $1 \text{ kV} < U_n \leq 35$  kV;
- High voltage (HV) refers to  $35 \text{ kV} < U_n \leq 220$  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  $\leq 16$  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

$\psi_k$

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:

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

where

$U_{\text{fic,min}}$  and  $U_{\text{fic,max}}$  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;

$S_{\text{k, fic}}$  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  $Ae^{j\theta_0}$  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:

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

where  $\underline{a} = e^{j2\pi/3}$  is the 120-degree operator, and  $X_{L1}$ ,  $X_{L2}$  and  $X_{L3}$  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  $U_{L1} = Ue^{j\theta}$ ,  $U_{L2} = Ue^{j(\theta+4\pi/3)}$  and  $U_{L3} = Ue^{j(\theta+2\pi/3)}$  then  $U_1 = (Ue^{j\theta} + e^{j2\pi/3} Ue^{j(\theta+4\pi/3)} + e^{j4\pi/3} Ue^{j(\theta+2\pi/3)})/3 = (Ue^{j\theta} + Ue^{j\theta} + Ue^{j\theta})/3 = Ue^{j\theta}$ .

[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 L1, L2 and L3, 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:

$$\underline{X}_2 = \frac{1}{3}(\underline{X}_{L1} + \underline{a}^2\underline{X}_{L2} + \underline{a}\underline{X}_{L3})$$

where  $\underline{a} = e^{j2\pi/3}$  is the 120-degree operator, and  $X_{L1}$ ,  $X_{L2}$  and  $X_{L3}$  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  $U_{L1} = Ue^{j\theta}$ ,  $U_{L2} = Ue^{j(\theta+4\pi/3)}$  and  $U_{L3} = Ue^{j(\theta+2\pi/3)}$  then  $U_2 = (Ue^{j\theta} + e^{j4\pi/3} Ue^{j(\theta+4\pi/3)} + e^{j2\pi/3} Ue^{j(\theta+2\pi/3)})/3 = Ue^{j\theta} (1 + e^{j2\pi/3} + e^{j4\pi/3})/3 = 0$

[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:

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

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  $|\underline{X}_2/\underline{X}_1|$  (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.

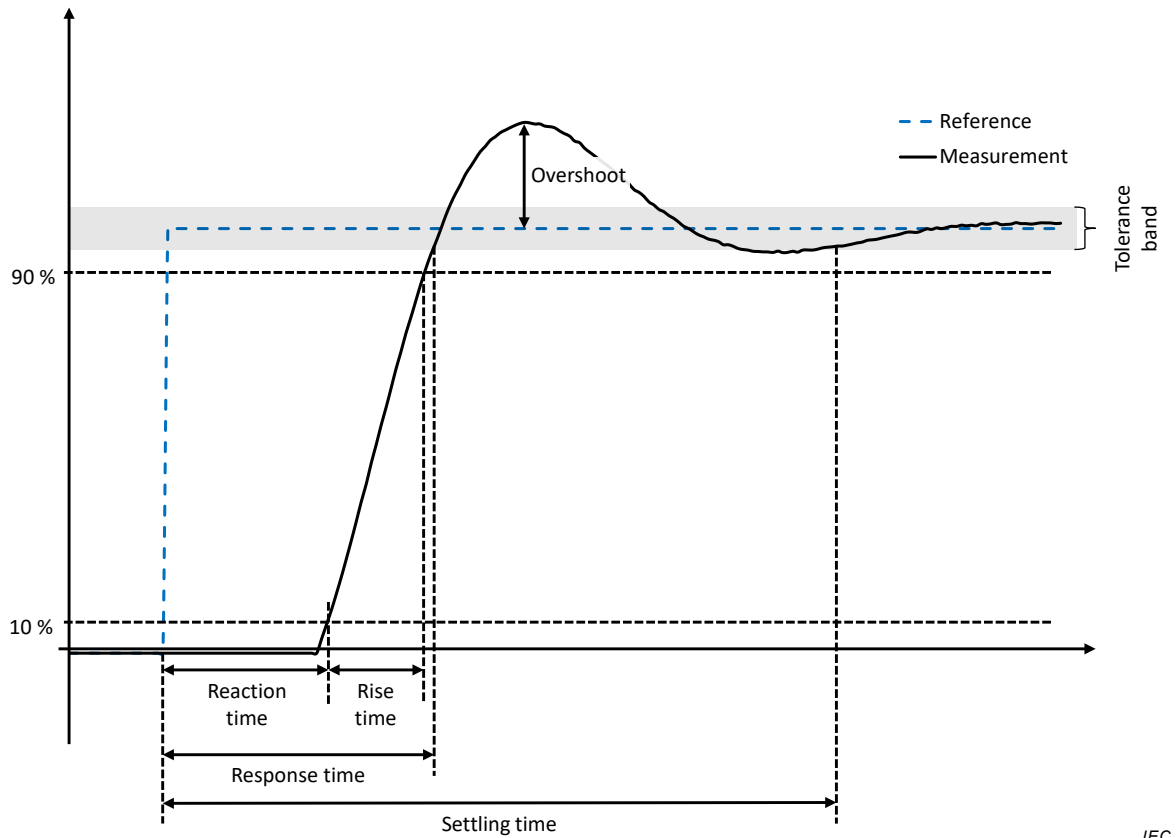


Figure 1 – Example of step response

**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  $\pm 10\%$  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  $\pm 10\%$  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