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TECHNICAL SPECIFICATION

colour inside

Distributed energy resources connection with the grid – Part 41: Requirements for frequency measurement used to control distributed energy resources (DER) and loads

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

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

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Part 41: Requirements for frequency measurement used to control distributed energy resources (DER) and loads

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IEC TS 62786-41 has been prepared by IEC technical committee 8: System aspects of electrical energy supply. It is a Technical Specification.

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

Draft	Report on voting
8/1649/DTS	8/1661/RVDTS

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

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

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

It has been developed as part of measurement series together with IEC TS 62786-42 on voltage measurement.

A list of all parts in the IEC 62786 series, published under the general title *Distributed energy resources connection with the grid*, 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 webstore.iec.ch in the data related to the specific document. At this date, the document will be

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- withdrawn,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

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DISTRIBUTED ENERGY RESOURCES CONNECTION WITH THE GRID –

Part 41: Requirements for frequency measurement used to control distributed energy resources (DER) and loads

1 Scope

This part of IEC 62786, which is a Technical Specification, defines minimum requirements for frequency and rate of change of frequency measurements used to control distributed energy resources (DER) and loads connected to electrical power networks.

This document specifies the characteristics of frequency and rate of change of frequency measurements to evaluate their performances. It describes the main use cases of frequency and rate of change of frequency measurements, with associated level of performances. It describes the principle of functional tests to evaluate the specified characteristics and defines the influencing factors that affect these performances, under steady state or dynamic conditions.

This document defines the functional requirements applicable to frequency and rate of change of frequency measurements which can be inside or outside the DER or loads. In the case of DER, this document provides requirements additional to those which are defined in the other parts of IEC 62786 or standards produced by the relevant IEC technical committees (e.g. TC 82 for photovoltaic systems, TC 88 for wind systems, TC 120 for electrical energy storage systems (EES)).

This document is applicable to DER and loads regardless of the voltage level of the point of connection to the grid.

This document does not specify hardware, software or a method for frequency or rate of change of frequency measurement. It does not specify tests linked to environmental conditions associated with hardware devices (climatic, electromagnetic disturbances above 3 kHz, mechanical stress, etc.).

Frequency and rate of change of frequency measurements associated with time stamping are not in the scope of this document. These measurements are already covered by IEC 60255-118-1 [1][1].

Frequency and rate of change of frequency measurements associated with protection functions or protection relays are not in the scope of this document. These requirements are already covered by IEC 60255-181 [2].

NOTE As defined in the first paragraph, this document is focused on frequency and rate of change of frequency measurements used to control DER and loads. But the technical requirements defined in this document, with the list of declared characteristics and their associated functional tests, can also be applicable for other uses where "fast" frequency and ROCOF measurement is required (small or large generators of power substations connected to transmission or distribution grids, power meter devices, power quality instruments, etc.).

2 Normative references

There are no normative references in this document.

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1 Numbers in square brackets refer to the Bibliography.

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
instrument
<for frequency measurement> device or measurement function which performs frequency or ROCOF measurement

Note 1 to entry: As the frequency or ROCOF measuring functions can be performed inside different types of devices or systems (control system of distributed energy resources, power system loads, protection relays, metering devices, etc.), the generic term "instrument" is used in this document to designate frequency or ROCOF measuring function which must be characterized and tested.

3.2
rotating vector
representation of a sinusoidal function where a polar vector rotates at an angular velocity which can be a non-constant function of time and is expressed in radians per second

Note 1 to entry: The radius of the rotating vector can also be a non-constant function of time.

Note 2 to entry: Rotating vectors can represent periodic or non-periodic sinusoids.

Note 3 to entry: Power system signals can be represented by a combination of signals, each represented by one rotating vector, each with various angular velocities and various radii. Each of these rotating vectors represents one component of the power system signal (see Annex E).

Note 4 to entry: The noise component of a power system signal is not represented by a rotating vector. Noise is represented as a time series.

3.3
phase
angle of a rotating vector

Note 1 to entry: When the rotating vector is described in polar notation, the phase is the angle; when described in complex notation, the phase is the argument.

3.4
instantaneous phase
phase of a rotating vector at a specific moment of time

Note 1 to entry: Any point along a sinusoidal periodic function can be represented by a complex number. The instantaneous phase is the argument of that complex number.

3.5
frequency
rate of change of phase of a rotating vector

Note 1 to entry: If the period is a span of time, the unit of frequency is hertz (Hz) in cycles per second.

Note 2 to entry: Frequency can be a non-constant function of time.

3.6
power frequency
values of frequency used in the electricity supply systems

[SOURCE: IEC 60050-601:1985, 601-01-05, modified – In the definition, "conventionally" has been deleted.]

3.7
instantaneous frequency
rate of change of instantaneous phase

Note 1 to entry: Typical frequency reporting instruments report instantaneous frequency and can report the changing frequency within one period of the input energizing quantity.

3.8
measured frequency
estimated frequency provided by an instrument

3.9
fundamental component
rotating vector of interest for a waveform that is a sum of rotating vectors

Note 1 to entry: Generally, the fundamental component is the rotating vector with the greatest magnitude; sometimes it is the component with the lowest frequency (often called the first harmonic). However, neither is always the case, for example in AC current waveforms or in oscillating signals with sub-harmonics.

3.10
fundamental frequency
frequency of the fundamental component

Note 1 to entry: In AC electrical power systems, the fundamental frequency is to be maintained within relevant statutory deviation from the nominal frequency.

Note 2 to entry: In three-phase systems, measuring fundamental frequency for all three phases can yield slightly different measurements due to interference. Frequency can be obtained by a transformation of the individual phases such as by averaging the three frequency measurements or by calculating the rate change of instantaneous phase of the positive sequence since positive sequence cancels common-mode interference.

[SOURCE: IEC 60050-103:2009, 103-07-21, modified – In the definition, "of a periodic quantity" has been deleted. Notes 1 and 2 to entry have been added.]

3.11
nominal frequency
nominal value of power frequency

Note 1 to entry: In conventional power systems, nominal frequency is normally 50 Hz or 60 Hz.

3.12
rate of change of frequency
ROCOF
first time derivative of instantaneous frequency or second time derivative of instantaneous phase

3.13
harmonic component
rotating vector whose frequency is an integer multiple of the fundamental frequency for a signal that is the sum of rotating vectors

Note 1 to entry: The fundamental component is the first harmonic component.

3.14
interharmonic component
rotating vector whose frequency is not an integer multiple of the fundamental frequency for a signal that is a sum of rotating vectors

3.15
sub-harmonic component
interharmonic component having harmonic order lower than one

[SOURCE: IEC 60050-103:2009, 103-07-29]

3.16
settling time
for a step response the duration of the time interval between the instant of the step change of an input variable and the instant, when the difference between the step response and their steady-state value remains smaller than the transient value tolerance

SEE: Figure 3

[SOURCE: IEC 60050-351:2013, 351-45-37, modified – Figure 5 inside the terminology entry has been replaced by Figure 3.]

3.17
fast frequency response
FFR
fast active power response to frequency variations that uses a droop control

3.18
droop control
<for frequency measurement> control loop to control dispatchable generators or loads to ensure that the active power generation or consumption is a proportional function of the measured power frequency deviation

Note 1 to entry: The proportionality factor is an inverse of the frequency droop.

3.19
frequency droop
ratio of the per-unit changes in frequency $(\Delta f)/f_n$ to the per-unit change in power $(\Delta P)/P_n$

$\sigma = (\Delta f/f_n) / (\Delta P/P_n)$,

where f_n is the nominal frequency and P_n is the DER or load rated power

Note 1 to entry: The frequency droop is a $f(P)$ function, whereas often used characteristic curve is $P(f)$.

Note 2 to entry: The same principle can be applied for a voltage droop.

Note 3 to entry: The frequency gradient of a characteristic curve, which describes the power response to frequency, is the active power change per frequency change. In a 50 Hz system, a droop of σ % can be transformed into a gradient g % (in P_n/Hz) by the formula $g = 200/\sigma$; in a 60 Hz system $g = 166{,}7/\sigma$.

3.20
synthetic inertia
<in an electric power system> capability of a grid connected converter to emulate the effect of inertia of a synchronous generator to a prescribed level of performance

Note 1 to entry: A static converter can provide synthetic inertia as a controlled response.

3.21
inertia
<in an electric power system> property of a rotating rigid body according to which it maintains its angular velocity in an inertial frame in the absence of an external torque

[SOURCE: IEC 60050-113:2011, 113-03-02, modified – The entry has been adapted for the purpose of a rotating reference system.]

3.22
measuring range
range defined by two boundary values of the measurand, or quantity to be supplied, within which the limits of accuracy are specified

[SOURCE: IEC 60050-311:2001, 311-03-12, modified – In the definition, "boundary" has been added and "uncertainty of the measuring instrument" has been replaced by "accuracy".]

3.23
operating range
range defined by two boundary values of the measurand, or quantity to be supplied, within which the instrument performs its intended measurements without entering in any kind of saturation mode that requires a recovery time when the input returns into the measuring range.

3.24
effective resolution
practical lower limit of a measurement due to inherent noise and errors

3.25
distributed energy resources
DER
generators, including loads having a generating mode (such as electrical energy storage systems) connected to the low or medium voltage distribution network, with their auxiliaries, protection and connection equipment

[SOURCE: IEC TS 62786:2017, 3.3, modified – The term has been made plural.]

3.26
input energizing quantity
energizing quantity that by itself constitutes the characteristic quantity, or helps to constitute it

Note 1 to entry: For the frequency or ROCOF measurement, the input characteristic quantity could be voltage.

[SOURCE: IEC 60050-447:2020, 447-03-02, modified – The notes to entry have been replaced by a new Note 1 to entry.]

3.27
flicker
impression of unsteadiness of visual sensation induced by a light stimulus whose luminance or spectral distribution fluctuates with time

Note 1 to entry: Flicker phenomenon is due to voltage magnitude variation, which can be periodic or erratic, with a spectral decomposition between 0,5 Hz and 25 Hz.

[SOURCE: IEC 60050-161:1990, 161-08-13, modified – Note 1 to entry has been added.]

3.28
measurand
quantity intended to be measured

[SOURCE: ISO/IEC Guide 99:2007, 2.3]

3.29
total distortion factor
ratio of the RMS value of the total distortion content to the RMS value of an alternating quantity

Note 1 to entry: The total distortion factor depends on the choice of the fundamental component. If it is not clear from the context which one is used, an indication should be given.

[SOURCE: IEC 60050-551:2001, 551-20-16]