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Incorporating corrigendum June 2015

BSI Standards Publication

Requirements for micro-generating plants to be connected in parallel with public low-voltage distribution networks

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National foreword

This British Standard is the UK implementation of EN 50438:2013. It supersedes BS EN 50438:2007 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee GEL/8, Systems Aspects for Electrical Energy Supply.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 December 2013.

Amendments/corrigenda issued since publication

Date	Text affected
30 June 2015	Implementation of CENELEC Interpretation sheet 1 May 2015 in National annex NA

EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

EN 50438

December 2013

ICS 29.160.20

Supersedes EN 50438:2007

English version

Requirements for micro-generating plants to be connected in parallel with public low-voltage distribution networks

Exigences pour les installations de micro-génération destinées à être raccordées en parallèle avec les réseaux publics de distribution à basse tension

Anforderungen für den Anschluss von Klein-Generatoren an das öffentliche Niederspannungsnetz

This European Standard was approved by CENELEC on 2013-11-04. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Bulgaria, Croatia, Cyprus, the Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

CEN-CENELEC Management Centre: Avenue Marnix 17, B - 1000 Brussels

Ref. No. EN 50438:2013 E

National Annex NA
(informative)
Text of IS1 to EN 50438:2013

1 Application of EN 50438:2013 instead of EN 50438:2007

Clause

Foreword (dow) 2016-11-04

In its foreword, the latest date by which the national standards conflicting with EN 50438:2013 have to be withdrawn, is fixed to 2016-11-04.
It has been reported that the EN 50438:2013 has some new functionalities that are not yet available in current state-of-the art micro-generators.

Question

What considerations should be made when using EN 50438:2013 instead of EN 50438:2007?

Interpretation:

When a CENELEC standard is published, it contains a date of publication and a date of withdrawal defining the timeframe within which the national standards should be adapted to this new CENELEC standard.

Generally, the date of withdrawal is about 2½ years after the date of publication creating an overlap period where the new standard can co-exist with a conflicting one. In the specific case where a standard has been revised, different versions of a same standard can therefore co-exist. This is the case for EN 50438.

The latest version has been available since December 2013 and until the date of withdrawal (2016-11-04), the previous version of 2007 can still be applied.

In the EN 50438:2013 version, the two most significant changes in the technical requirements to the EN 50438:2007 version are the following:

- introduction of a power reduction capability in case of over-frequency;
- introduction of reactive power capability

TC 8X wants to emphasize that the over-frequency response requirements as described in EN 50438:2013 are important for grid stability and should be applied as soon as possible. The over-frequency response function is commonly implemented in the considered range of generating units.

However, there are other new requirements (e.g. providing reactive power) which are actually not yet commonly implemented in the considered range of generating units. For these new requirements, the industry might need appropriate time to modify their products. Often micro-generators are also certified by independent certification bodies which adds more time to the manufacturing and testing process. For the implementation of these requirements, a period of at least 18 months is considered reasonable.

These aspects should be considered when using EN 50438:2013 instead of EN 50438:2007.
When using EN 50438:2013, there may be a need to wait up to July 2015 for the application of Subclause 4.3.1.

2 Interpretation on power response to over-frequency

2.1 Subclause 4.2.5 Power response to over-frequency of EN 50438:2013

It has been reported that the function of the intentional delay to the power response to over frequency may be differently interpreted.

The generator shall be capable of activating active power frequency response as fast as technically feasible with an initial delay that shall be as short as possible with a maximum of 2 s. If the initial delay is below 2 s an intentional delay shall be programmable to adjust the total response time to a value between the initial response time and 2 s.

It is not clear from the above paragraph of Subclause 4.2.5 whether the programmable intentional delay is a permanent delay (dead time) within the function or whether it is only a delay to start the execution of the function.

2.2 Question:

Is the intentional delay integrated into the control loop (dead time) of the active power setpoint in case of over-frequency or is it only delaying the activation of the active power control?

2.3 Interpretation:

With the provision described in Subclause 4.2.5 of EN 50438:2013, the intentional delay is only active for the activation of the function, once the function is operating, the established control loop is not intentionally delayed.

NOTE 1 The option of an intentional delay is required since a very fast and undelayed active power frequency response in case of islanding would correct any excess of generation leading to a generation-consumption balance. In these circumstances, an islanding situation with stable frequency would take place, in which the correct behaviour of any LoM detection based on frequency might be hindered.

NOTE 2 The intentional delay is considered relevant for power system stability. For that reason legal regulations might require a mutual agreement on the setting between DSO and TSO.

Contents

Foreword

This document (EN 50438:2013) has been prepared by CLC/TC 8X "System aspects of electrical energy supply".

The following dates are fixed:

• latest date by which this document has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2014-11-04
• latest date by which the national standards conflicting with this document have to be withdrawn	(dow)	2016-11-04

This document supersedes EN 50438.2007.

EN 50438:2013 includes the following significant technical changes with respect to EN 50438:2007:

– introduction of a power reduction capability in case of over-frequency;

– introduction of reactive power capability

– update of national protection parameters settings in Annex A;

– modification of tests for the verification of interface protections (voltage and frequency);

– modification of the test for islanding detection;

– addition of a test for direct current injection.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CENELEC [and/or CEN] shall not be held responsible for identifying any or all such patent rights.

This document has been prepared under a mandate given to CENELEC by the European Commission and the European Free Trade Association.

This European Standard relates to both future European Network Codes and current technical market needs. Its purpose is to give detailed description of functions to be implemented in products and methods to verify the compliance of the products.

This European Standard is also intended to serve as a technical reference for the definition of national requirements where European Network Codes requirements allow flexible implementation, e.g. settings for power response to over frequency.

CLC/TC 8X plans to review the Standard periodically, in order to ensure its compatibility with the evolution of the legal framework.

1 Scope

This European Standard specifies technical requirements for the protection functions and the operational capabilities of micro-generating plants, designed for operation in parallel with public low-voltage distribution networks.

This European Standard applies irrespectively of the micro-generating plants' primary source of energy, where micro-generation refers to equipment with nominal currents up to and including 16 A per phase, single or multi phase 230/400 V or multi phase 230 V (phase-to-phase nominal voltage).

For practical reasons, this European Standard refers to the distribution system operator in case settings have to be defined and/or provided, even when these settings are to be defined and/or provided by another actor according to national and European legal framework.

NOTE 1 This includes European network codes and their national implementation, as well as further national regulations.

NOTE 2 Further national requirements especially for the connection to the grid and the operation of the micro-generator can apply as long as they are not in conflict with this EN.

In some countries, this document may be applied to generators with higher nominal currents used mostly in domestic and small commercial installations. These countries are listed in Annex G.

The provisions of this European Standard are not intended to ensure by themselves the safety of DSO personnel or their contracted parties.

The following aspects are included in the scope:

- all micro-generation technologies are applicable.

The following aspects are excluded from the scope:

- multiple units that for one installation, in aggregate, exceed 16 A;
- issues of revenue rebalancing, metering or other commercial matters;
- requirements related to the primary energy source e.g. matters related to gas fired generator units;
- island operation of generating plants, both intentional and unintentional, where no part of the public distribution network is involved;
- active front ends of drives feeding energy back into the distribution network for short duration.

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.

EN 50110 (all parts), *Operation of electrical installations*

EN 50160, *Voltage characteristics of electricity supplied by public electricity networks*

HD 60364 (all parts), *Low-voltage electrical installations (IEC 60364 series)*

EN 61000-3-2:2006, *Electromagnetic compatibility (EMC) — Part 3-2: Limits — Limits for harmonic current emissions (equipment input current <= 16 A per phase) (IEC 61000-3-2:2005)*

EN 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 61000-3-3)*

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

EN 61000-6-1, *Electromagnetic compatibility (EMC) — Part 6-1: Generic standards — Immunity for residential, commercial and light-industrial environments (IEC 61000-6-1)*

EN 61000-6-3, *Electromagnetic compatibility (EMC) — Part 6-3: Generic standards — Emission standard for residential, commercial and light-industrial environments (IEC 61000-6-3)*

HD 60364-5-551, *Low-voltage electrical installations — Part 5-55: Selection and erection of electrical equipment — Other equipment — Clause 551: Low-voltage generating sets (IEC 60364-5-55:2001/A2:2008 (CLAUSE 551))*

IEC 60255-127, *Measuring relays and protection equipment — Part 127: Functional requirements for over/under voltage protection*

3 Terms and definitions

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

3.1
active factor
ratio of the active power to the apparent power, for a two-terminal element or a two-terminal circuit under sinusoidal conditions

Note 1 to entry: In a three phase system this is referring to the positive sequence.

Note 2 to entry: The active factor is equal to the cosine of the displacement angle.

3.2
cogeneration
combined heat and power
CHP
combined generation of electricity and heat by an energy conversion system and the concurrent use of the electric and thermal energy from the conversion system

Note 1 to entry: In the context of small-scale generation this concept is sometimes referred to as “micro-CHP”.

3.3
commissioning
process of putting into operation a micro-generator, apparatus, equipment, building, or facility

3.4
decommissioning
process of removing a micro-generator, apparatus, equipment, building, or facility from operation

3.5
disconnection
separation of the active parts of the micro-generator from the network with mechanical contacts providing at least the equivalent of basic insulation

Note 1 to entry: Passive components like filters, auxiliary power supply to the micro-generator and sense lines can remain connected.

Note 2 to entry: For the design of basic insulation all voltage sources will be considered.

3.6
displacement angle
phase difference angle under sinusoidal conditions, phase difference between the voltage applied to a linear two-terminal element or two-terminal circuit and the electric current in the element or circuit

Note 1 to entry: In a three phase system this is referring to the positive sequence.

Note 2 to entry: The cosine of the displacement angle is the active factor.

3.7
LV distribution network
low voltage part of the electric power system used for the transfer of electricity within an area of consumption to consumers

3.8
distribution system operator
DSO
natural or legal person responsible for operating, ensuring the maintenance of and, if necessary, developing the distribution network in a given area and, when applicable, its interconnections with other systems and for ensuring the long term ability of the system to meet reasonable demands for the distribution of electricity

3.9
droop
ratio of the per-unit change in frequency $(\Delta f)/f_n$ (where f_n is the nominal frequency) to the per-unit change in power $(\Delta P)/P_M$ (where P_M is the actual active power at the instance when the frequency reaches the frequency threshold used to activate the droop control):

$$s = - (\Delta f/f_n) / (\Delta P/ P_M)$$

[SOURCE: IEV 603-04-08, modified — the full definition has been altered.]

3.10
electrical installation
assembly of wiring and electrical equipment that is used within the domestic premises for the distribution and/or use of electric energy

3.11
inform and fit
process of installing and commissioning a micro-generator with prior notification of the DSO, followed by commencement of operation without the need of prior formal approval of the DSO

3.12
installer[1)]
person who has received sufficient training to apply safe methods of work to install a micro-generator in compliance with the requirements of this standard

3.13
interface protection
electrical protection required to ensure that the micro-generator is disconnected for any event that could impair the integrity or degrade the safety of the distribution network

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1) Based on national regulations, other terms may apply.

3.14
Interface protection system timing

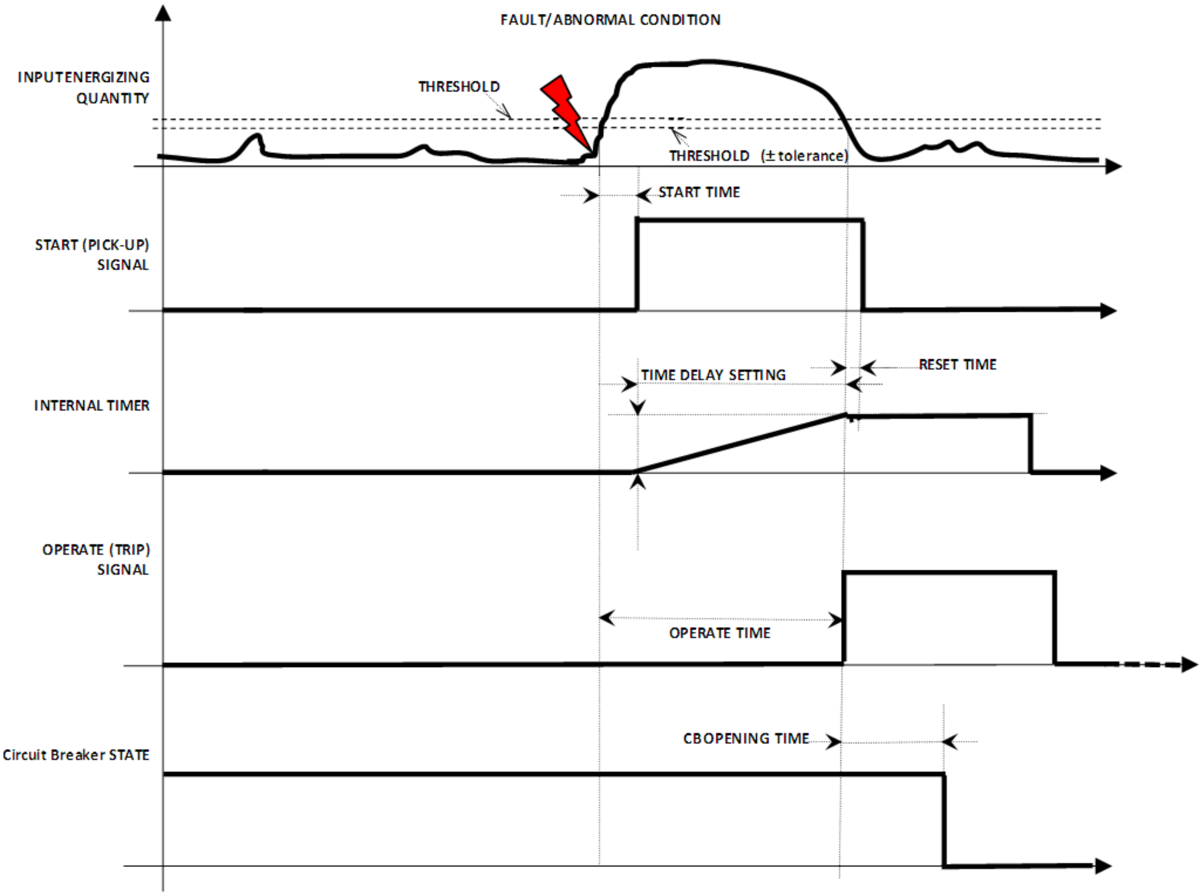

Figure 1 — Main times defining interface protection performance

3.14.1
energising quantity
energising quantity by which the protection function is activated when it is applied under specified conditions

Note 1 to entry: See also Figure 1.

[SOURCE: IEV 442-05-58, modified — the full definition has been altered.]

3.14.2
time delay setting
intentional delay that might be adjustable by the user

Note 1 to entry: See also Figure 1.

3.14.3
start time
duration of the time interval between the instant when the characteristic quantity of the measuring relay in reset condition is changed, under specified conditions, and the instant when the start signal asserts

Note 1 to entry: See also Figure 1.

[SOURCE: EN 60255-151:2009, 3.5]

3.14.4
operate time (from)
duration of the time interval between the instant when the characteristic quantity of a measuring relay in reset condition is changed, under specified conditions, and the instant when the relay operates

Note 1 to entry: See also Figure 1.

Note 2 to entry: Operate time is start time plus time delay setting.

[SOURCE: IEV 447-05-05, modified — Note 2 to entry has been added.]

3.14.5
reset time
duration of the time interval between the instant when the characteristic quantity of a measuring relay in operate condition is changed, under specified conditions, and the instant when the relay resets

Note 1 to entry: See also Figure 1.

[SOURCE: IEV 447-05-06]

3.14.6
disconnection time
sum of operate time of the protection system and the opening time (CB opening time in Figure 1) of the interface switch

3.15
islanding
situation where a section of the electricity network, containing generation, becomes physically disconnected from the rest of the public distribution network or user's network and one or more generators maintain a supply of electrical energy to the isolated section of the network

3.16
isolation
cut off for reasons of safety from all or a discrete section of the electrical installation by separating the electrical installation or section from every source of electrical energy

3.17
Loss of Mains (LoM) detection
function that will detect the micro-generator operating in an islanding situation

3.18
low voltage
LV
voltage whose nominal r.m.s. value is $U_n \leq 1$ kV

3.19
micro-generator
source of electrical energy and all associated interface equipment able to be connected to a regular electric circuit in a low voltage electrical installation and designed to operate in parallel with a public low voltage distribution network with nominal currents up to and including 16 A per phase

[SOURCE: IEV 617-04-10, modified — the content of an original Note after the definition has been included at the end of the present definition.]

3.20
micro-generating plant
electrical installation with one or more micro-generators with nominal currents in sum not exceeding 16 A per phase

3.21
nominal voltage
U_n
voltage by which a supply network is designated or identified and to which certain operating characteristics are referred

3.22
notification
process of informing the DSO of the commissioning of a micro-generation system, or its decommissioning

3.23
operate value
value of the input energising quantity (or characteristic quantity) at which a measuring relay operates

Note 1 to entry: See also Figure 1.

[SOURCE: IEV 447-02-10, modified — Note 1 to entry with the cross-reference to Figure 1 has been added.]

3.24
point of connection
POC
interface at which the generating plant is connected to a public distribution network

3.25
quality factor
Q_f
measure of the strength of resonance of the islanding test load

Note 1 to entry: In a parallel resonant circuit, such as a load on a power system:

$$Q_f = R\sqrt{\frac{C}{L}}$$

where

Q_f is quality factor;
R is effective load resistance;
C is reactive load capacitance (including shunt capacitors);
L is reactive load inductance.

With C and L tuned to the power system fundamental frequency, Q_f for the resonant circuit drawing active power, *P,* reactive powers Q_L, for inductive load and Q_C for capacitive load, Q_f can be determined by:

$$Q_f = \left(\frac{1}{P}\right)\sqrt{|Q_L|.|Q_C|}$$

where
P is active power, in W;
Q_L is inductive load, in VAr_L;
Q_C is capacitive load, in VAr_C.

3.26
power factor
under periodic conditions, ratio of the absolute value of the active power P to the apparent power S:

$$\lambda = \frac{|P|}{S}$$

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

[SOURCE: IEV 131-11-46]

3.27
simple separation
separation between electric circuits or between an electric circuit and local earth by means of basic insulation

[SOURCE: IEV 826-12-28]

3.28
stationary fuel cell power system
generator system that uses a fuel cell module to generate electrical power and heat that is connected and fixed in place

[SOURCE: IEC/TS 62282-1:2010, 3.49 and 3.49.3, modified — the two original definitions have been combined.]

3.29
switch-disconnector
switch which, in the open position, satisfies the isolating requirements specified for a disconnector

[SOURCE: IEV 441-14-12]

3.30
user
person with responsibility for the premises in which the micro-generator is installed, normally referred to in other documentation as the customer / consumer / network user

4 Technical requirements

4.1 Electrical installation

4.1.1 General

Low voltage electrical installations shall comply with national and local regulation.

In case of any hardware malfunctioning, disconnection is required.

NOTE Only such hardware malfunctioning is taken into account that is relevant for the compliance of the micro-generating plant with this standard.

4.1.2 Over-current protection

The micro-generating plant shall be protected against over-current according to the HD 60364 series. When selecting the over-current protection within the domestic installation it is necessary to ensure correct selectivity with the DSO's protection devices.

4.1.3 Earthing

Earthing shall be according to HD 60364-5-551 and the relevant national standards.

When a micro-generator is operating in parallel with the distribution network, there shall be no direct connection between the generator winding (or pole of the primary energy source in the case of a DC sourced micro-generator) and the DSO's earth terminal. For installations where the customer provides his own earth terminal, e.g. when connected to a TT system, it is also advisable to avoid connecting the generator winding to this earth terminal.

NOTE The reason for this precaution is to avoid damage to the generator during faults on the distribution network and to ensure correct operation of protective devices.

For a micro-generator which is designed to operate in parallel with a distribution network but which is connected via an inverter (e.g. a PV array or a stationary fuel cell power system) it is permissible to connect one pole of the DC side of the inverter to the distribution network if there is insulation between the AC and the DC sides of the inverter. In such cases, the installer/manufacturer shall take all reasonable precautions to ensure that the micro-generator will not impair the integrity of the distribution network and will not suffer unacceptable damage for all credible operating conditions, including faults on the distribution network.

4.2 Normal operating range

4.2.1 General

Generating plants have to be able to operate in the operating range specified below regardless the topology and the settings of the interface protection.

4.2.2 Continuous voltage operation range

The generating plant shall be capable not to disconnect due to voltage when the voltage at the point of connection stays within the range of 0,85 U_n to 1,1 U_n.

The generating plant owner shall take into account the voltage rise and voltage drop within the installation when considering the wider operating range for the generator unit itself.

NOTE For future trends, it is assumed that disconnection due to short time disturbances, voltage dips up to several hundreds of ms, is not allowed unless the protection settings demand a disconnection.

4.2.3 Continuous frequency operation range

The generating plant shall be capable to operate continuously when the frequency at the point of connection stays within the range of 49 Hz to 51 Hz.

Linear generators, coupled directly and synchronously to the grid, and powered by free piston stirling engines are permitted to disconnect below 49,5 Hz and above 50,5 Hz.

NOTE The exception for linear generators is under discussion in the framework of the development of European network codes and may be removed by the next revision of this standard.

4.2.4 Response to under-frequencies

A generating plant shall be resilient to reductions of frequency at the point of connection while reducing the maximum power as little as possible.

Table 1 — Minimum time periods for operation in under-frequency situation

Frequency range	Time period for operation
47,5 Hz – 49 Hz	30 min

Table 1 shows the minimum time periods a generating plant has to be able to operate without disconnecting from the network.

NOTE Respecting the legal framework, it is possible that a more stringent requirement regarding minimum time periods for operation in under-frequency situation are required by the DSO in coordination with the TSO.

The admissible active power reduction due to under-frequency below 49,5 Hz is limited by a reduction rate of 10 % of the momentary power P_M per 1 Hz frequency drop as given by the full line in Figure 2.

Respecting the legal framework, it is possible that a more stringent power reduction characteristic is required by the DSO in coordination with the TSO. Nevertheless this requirement shall be limited to an admissible active power reduction due to under-frequency below 49,0 Hz with a reduction rate of 2 % of the momentary power P_M per 1 Hz frequency drop as indicated by the dotted line in Figure 2.

Acceptance of this reduction is limited to a selection of affected generation technologies and may be subject to further conditions decided by the relevant TSO.

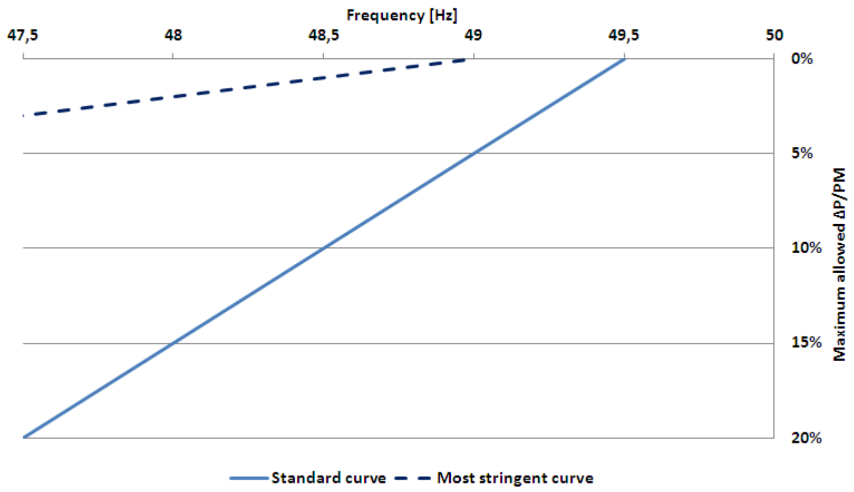

Figure 2 — Maximum allowable power reduction in case of under-frequency

4.2.5 Power response to over-frequency

A generating plant shall be resilient to over-frequency at the point of connection.

Table 2 — Minimum time periods for operation in over-frequency situation

Frequency range	Time period for operation
51 Hz – 51,5 Hz	30 min

Table 2 shows the minimum time periods a generating plant has to be able to operate without disconnecting from the network.

NOTE 1 Respecting the legal framework, it is possible that a more stringent requirement regarding minimum time periods for operation in over-frequency situation are required by the DSO in coordination with the TSO.

Unless otherwise required by the DSO, the micro-generating plant shall be capable of activating active power frequency response at a programmable frequency threshold f_1 at least between and including 50,2 Hz and 52 Hz with a programmable droop in a range of at least 2 % – 12 %. The droop is relative to P_M, the actual AC output power at the instance when the frequency reaches the threshold f_1. The resolution of the frequency measurement shall be +/- 10 mHz or less. After the programmable intentional delay, the active power frequency response shall be delivered with an accuracy of ± 10 % P_n and with a settling time less than 2 s.

NOTE 2 Respecting the legal framework, it is possible that, alternative to P_M, the maximum power is required as a reference by the DSO in coordination with the TSO.

NOTE 3 The active power droop might also be defined as an active power gradient relative to the actual power P_M. A droop in the range of 2 % - 12 % represents a gradient of 100 % P_M /Hz – 16,7 % P_M /Hz.

The generator shall be capable of activating active power frequency response as fast as technically feasible with an initial delay that shall be as short as possible with a maximum of 2 s. If the initial delay is below 2 s an intentional delay shall be programmable to adjust the total response time to a value between the initial response time and 2 s.

After activation, the frequency droop function shall use the actual frequency at any time.

If the initial delay is greater than 2 s it shall be reasonably justified by the manufacturer to the DSO.

The settings for the threshold frequency f1, the droop and the intentional delay are provided by the DSO and shall be field adjustable. If no settings are provided, the default settings in Table 3 shall be applied.

For field adjustable settings means shall be provided to protect the settings from unpermitted interference (e.g. password or seal) if required by the DSO.

When applying active power response to over-frequency, the frequency threshold f1 should be set to a value from 50,2 Hz up to 50,5 Hz.

NOTE 4 Setting the frequency threshold f1 to 52 Hz is considered as deactivating this function.

Table 3 — Standard settings for power response to over-frequency

Parameter	Value
Threshold frequency	50,2 Hz
Droop	5 %
Intentional delay	0 s

It shall be taken into account that, in case of islanding, a power reduction would correct any excess of generation leading to a generation-consumption balance. In these circumstances, an islanding situation with stable frequency would take place, in which the correct behaviour of any LoM detection based on frequency as those mentioned in 4.6.2 (Table 4) might be hindered.

Generators for which it is technically not feasible to reduce power over the full droop range in the required time shall activate active power frequency response as above in the fast controllable range of output power. Once the limit of fast controllable frequency response is reached, this power level is maintained constant. The unit has to shut off at a random frequency between the frequency threshold f_1 and f_{max}; with f_{max} the disconnection limit for over-frequency as provided by the DSO. If no setting is provided, the default setting for f_{max} is 51,5 Hz.

After European Network Codes will come into force, the decision about the ability should be according to the derogation process.

The overall effect on transmission network level of multiple units with the random frequency disconnection function should emulate the droop curve given by Table 1 resp. the setting in Annex A.

NOTE 5 PV is considered to have the ability to reduce power over the full droop range.

NOTE 6 Interface protection functioning overrules this behaviour.

NOTE 7 Similar functions as response to under-frequency are under consideration.

After a frequency excursion, once the frequency drops below the threshold frequency f_1 the micro-generating plant is allowed to rise the power above P_M. The active power generated by a generating plant shall not exceed the specified gradient expressed as a percentage of the active nominal power of the unit per minute. If no gradient is specified by the DSO, the default setting is 10 % P_n/min. Non-adjustable or partly adjustable generating plant that have been disconnected shall reconnect according to 4.7.2.

4.3 Reactive power capability

4.3.1 Inverter based micro-generator

The micro-generator shall be capable to operate, under normal stationary operating conditions in the voltage tolerance band according to 4.2.2, with the following reactive power exchange (see Figure 3):

- following a characteristic curve provided by the DSO (see 4.4) within the active factors $\cos \varphi = 0{,}90_{under\text{-}excited}$ to $0{,}90_{over\text{-}excited}$ when the active power output of the micro-generator is more than or equal to 20 % of its nominal active power;
- not exchanging more reactive power than 10 % of the micro-generator's nominal active power when the active power output is less than 20 % of its nominal active power.

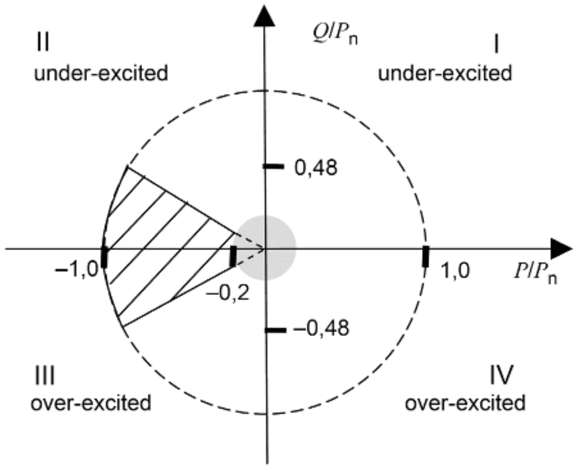

Figure 3 — Reactive power capability in load reference frame

NOTE In an under-excited operation, the micro-generator absorbs vars. In an over-excited operation, the micro-generator delivers vars.

4.3.2 Directly coupled micro-generator with no inverter

The power factor of the micro-generator at normal steady-state operating conditions across the statutory tolerance band of nominal voltage shall be above 0,95, provided the output active power of the micro-generator is above 20 % the nominal output power of the unit. Below 20 % nominal output power the micro-generator shall not exchange more reactive power than 10 % of its nominal active output power.

4.4 Reactive power control modes

4.4.1 General

Only when a reactive power exchange capability following a characteristic curve is required (see 4.3), the requirements of 4.4.3 shall apply.

The control shall be delivered at the terminals of the micro-generator. The micro-generator shall be capable of operating in the following control modes within the limits stated in 4.3:

- Q (U);
- cos φ fix;
- cos φ (P).

The configuration of the control modes shall be field adjustable. The activation and deactivation of the control modes shall be field adjustable.

For field adjustable configurations and activation/deactivation of the control mode, means shall be provided to protect the settings from unpermitted interference (e.g. password or seal) if required by the DSO.

The accuracy for controlled reactive power shall be below ± 2 % of nominal power of the micro-generator. The accuracy is always stated in reactive power, even if the used control mode is referring to the active factor.

NOTE For evaluation of the active factor accuracy the reactive power is used because of the non-linearity of the active factor and because to the DSO only the reactive power is relevant, not the active factor. The active factor is only a mean to control reactive power.

The type of contribution to voltage control by reactive power shall be specified by the DSO. If no characteristic curve is specified by the DSO, the micro-generator shall operate with an active factor = 1.

4.4.2 Fix control mode cos φ fix

The fix control mode controls the active factor cos φ of the micro-generator's output according to a setpoint set in the control of the micro-generator.

4.4.3 Voltage related control mode Q(U)

The voltage related control mode Q(U) controls the reactive power output as a function of the voltage.

For evaluating the voltage one of the following methods shall be used:

- the positive sequence of the symmetrical components;
- the average voltage of a three phase system;
- phase independently the voltage of every phase to determine the reactive power for every phase.

A characteristic curve according to Figure 4 shall be configurable.

Additional to the characteristic the dynamic response of the control should be configurable. The dynamics of the control should correspond with a first order filter having a time constant that is configurable in the range of 3 s to 60 s. The time to reach 95 % of a new set point due to a change in voltage will be 3 times the time constant.

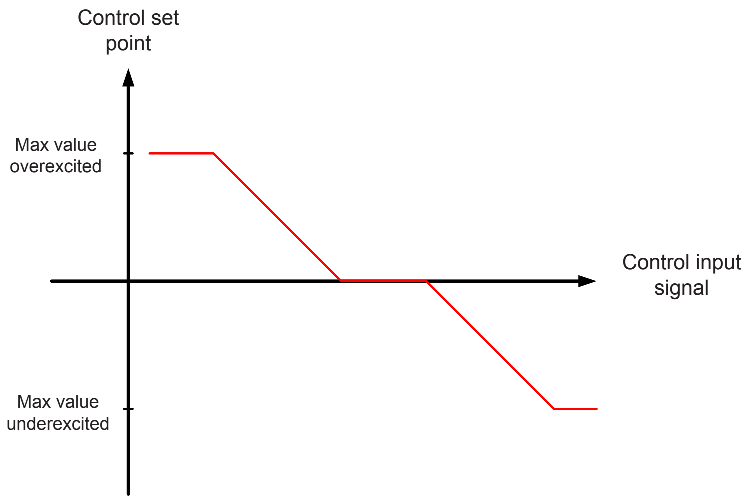

Figure 4 — Reactive power control characteristic

4.4.4 Power related control mode cos φ (P)

The power related control mode cos φ (P) controls the active factor cos φ of the micro-generator's output as a function of its active power output.

A characteristic according to Figure 4 has to be configurable.

New set values due to a change of the active power output have to be adjusted within a settling time of 10 s. The rate of change of reactive power should be in the same time range as and synchronised with the rate of change of active power.

4.5 Voltage control by active power

In order to avoid disconnection due to the over-voltage protection the micro-generating plant is allowed to reduce active power output as a function of this rising voltage. If this function is activated, the micro-generating plant may reduce active power according to a logic chosen by the manufacturer. Nevertheless, this logic shall not result in steps of output power.

4.6 Interface protection

4.6.1 General

4.6.1.1 Introduction

The purpose of the interface protection is to ensure that the connection of a micro-generator will not impair the integrity or degrade the safety of the distribution network. The interface protection shall be insensitive to voltage and frequency variations in the distribution network within the voltage and frequency settings.

The interface protection, monitoring and control functions may be incorporated into the micro-generator control system, or may be fitted as discrete separate mounted devices.

The interface protection settings shall be field adjustable.

For field adjustable settings means shall be provided to protect the settings from unpermitted interference (e.g. password or seal) if required by the DSO.

The protection functions have to evaluate at least all phases where micro-generators, covered by this protection system, are connected to.

In case of three phase generating units/plants and when the protection system is implemented as a external protection system in a three phase supply system, all phase to phase or all phase to neutral voltages have to be evaluated.

The frequency has to be evaluated on at least one of the supply voltages.

If multiple signals (e.g. three phase to phase voltages) are to be evaluated by one protection function, this function has to evaluate all of the signals separately. The output of each evaluation has to be OR connected, so that if one signal passes the threshold of a function, the function has to trip the protection in the specified time.

The minimum required accuracy is:

- for frequency measurement ± 0,05 Hz;
- for voltage measurement ± 1 % of U_n.

The measurement point can be inside the micro-generator or anywhere between the micro-generator terminals and up to the point of connection.

If the interface protection system is external to the generating unit, it should measure as close as possible to the point of connection. The voltage rise between the point of connection and the measurement input of the interface protection system should be kept as small as possible to avoid nuisance tripping of the overvoltage protection.

In order to avoid continuous starting and disengaging operations of the interface protection relay, the disengaging value of frequency and voltage functions shall be above 2 % deviating from the operate value.

4.6.1.2 Response to protection operation

The micro-generator shall disconnect from the network in response to an interface protection operation.

4.6.1.3 Place of the interface protection

The interface protection can either be incorporated within the micro-generator or implemented by separate devices. In either case, the interface protection shall meet the relevant requirements of IEC 60255-127 and the manufacturer of the micro-generator shall declare that the combined devices fulfil these requirements.

4.6.1.4 Changing settings of the interface protection

The interface protection settings may only be altered from the settings chosen at the time of commissioning or during later reconfiguration, with the written agreement of the DSO and then only in accordance with the manufacturer instructions. It shall not be permissible for the user to alter the interface protection settings.

NOTE Alteration of the settings of the interface protection may cause a breach of the type-certificate making re-testing necessary unless the micro-generator is type-tested on the full range of settings for the interface protection.

4.6.1.5 Combined protection device for multiple generators

It is allowed to use a protection system that provides interface protection for two or more micro-generators up to and including 16 A per phase in aggregate. However, the possibility to use Inform and Fit then depends on the conditions of the type of conformity assessment of the protection system.

If two or more micro-generators, each with their own interface device, are placed in parallel, the proper combined working of the protection devices shall be ensured.

In the case of adding a generator to the combined protection device, the DSO shall be consulted.

4.6.2 Interface protection settings

The interface protection settings are provided by the DSO. If no settings are provided, the default settings in Table 4 should be applied.

Table 4 — Default interface protection performance

Parameter	Maximum disconnection time	Minimum operate time	Trip value
Over-voltage – stage 1 [a]	3 s	-	230 V + 10 %
Over-voltage – stage 2	0,2 s	0,1 s	230 V + 15 %
Under-voltage	1,5 s	1,2 s	230 V – 15 %
Over-frequency	0,5 s	0,3 s	52 Hz
Under-frequency	0,5 s	0,3 s	47,5 Hz
LoM (if required)	See Annex A		See Annex A.
	The stated voltages are 'true r.m.s.' or fundamental component -values.		
	[a] Over-voltage – stage 1: 10-min-value corresponding to EN 50160. The calculation of the 10 min value shall comply with the 10 min aggregation of EN 61000-4-30, class S. The function shall be based on the calculation of the square root of the arithmetic mean of the squared input values over 10 min. In deviation from EN 61000-4-30, a moving window shall be used. The calculation of a new 10-min value at least every 3 s is sufficient, which is then to be compared with the trip value. Tolerances on disconnection time are ± 10 % .		

NOTE Voltage and frequency is referenced to the supply terminals of the micro- generator.

4.6.3 Requirements regarding single fault tolerance of interface protection system

The interface protection system consisting of the interface protection relay and the interface switch shall meet the requirements of single fault tolerance.

A single fault shall not lead to a loss of the safety functions. Faults of common cause shall be taken into account if the probability for the occurrence of such a fault is significant. Whenever reasonably practical, the individual fault shall be displayed and lead to the disconnection of the power generation unit or system.

NOTE This requirement for the detection of individual faults does not mean that all faults are detected. Accumulation of undetected faults can therefore lead to an unintentional output signal and to a hazardous state.

Series-connected switches shall each have independently a breaking capacity corresponding to the rated current of the micro-generator and corresponding to the short circuit contribution of the micro-generator.

The short-time withstand current of the switching devices shall be coordinated with maximum short circuit power at the connection point.

At least one of the switches shall be a switch-disconnector suitable for over-voltage category 2. For single-phase micro-generators, the switch shall have one contact of this over-voltage category each for both the neutral conductor and the line conductor. For poly-phase supply systems, it is required to have one contact of this over-voltage category each for all active conductors. The second switch may be formed by electronic switching components of an inverter bridge or another circuit provided that the electronic switching components can be switched off by control signals and that it is ensured that a failure is detected and leads to prevention of the operation at the latest at the next reconnection.

For PV-inverters without simple separation between the network and the PV generator (e.g. PV-Inverter without transformer) both switches mentioned in the paragraph above shall be switch-disconnectors with the requirements described therein, although one switching device is permitted to be located between PV generator and PV inverter.

4.7 Connection and starting to generate electrical power

4.7.1 General

Connection and starting to generate electrical power is only allowed after voltage and frequency is within the allowed voltage range and the allowed frequency range for at least the specified observation time. It shall be impossible to overrule these conditions. The setting of the conditions depends on whether the connection is due to a normal operational start-up or an automatic reconnection after tripping of the interface protection.

The frequency range, the voltage range, the observation time and the power gradient shall be field adjustable.

For field adjustable settings, means shall be provided to protect the settings from unpermitted interference (e.g. password or seal) if required by the DSO.

4.7.2 Automatic reconnection after tripping

If no settings are specified by the DSO, the default settings for the reconnection after tripping of the interface protection are:

- Frequency range: 47,5 Hz ≤ f ≤ 50,05 Hz;
- Voltage range: 0,85 U_n ≤ U ≤ 1,10 U_n;
- Minimum observation time: 60 s.

After reconnection the active power generated by the generating plant shall not exceed a specified gradient expressed as a percentage of the active nominal power of the unit per minute. If no gradient is specified by the DSO, the default setting is 10 % P_n/min. Non-adjustable or partly adjustable generating units may connect after 1 min to 10 min (randomised value) or later.

4.7.3 Starting to generate electrical power

If no settings are specified by the DSO the default settings for connection or starting to generate electrical power due to normal operational start-up or activity are:

- Frequency range: 47,5 Hz ≤ f ≤ 50,1 Hz;
- Voltage range: 0,85 Un ≤ U ≤ 1,10 Un;
- Minimum observation time: 60 s.

If applicable, the power gradient shall not exceed the maximum gradient specified by the DSO in the connection agreement. Heat driven CHP micro-generators do not need to keep a maximum gradient, since the start up is randomised by the nature of the heat demand.

For manual operations performed on site (e.g. for the purpose of initial start-up or maintenance) it is permitted to deviate from the observation time and ramp rate.

4.7.4 Synchronisation

Synchronising a micro-generator with the distribution network shall be fully automatic i.e. it shall not be possible to manually close the switch between the two systems to carry out synchronisation.

4.8 Power quality

4.8.1 General

As any other apparatus or fixed installation, micro-generators have to comply with the requirements on electromagnetic compatibility established in Directive 2004/108/EC.

They are also expected to be compatible with voltage characteristics at the point of connection to the public network, as described in 4.2.

NOTE EMC limits and tests, as described in EN 61000 series, have been traditionally developed for loads, without taking into account the particularities of generators, such as their capability to create over-voltages or high frequency disturbances due to the presence of power converters, which were either impossible or less frequent in case of loads. Currently, IEC/SC 77A is reviewing all their existing standards to include, where necessary, specific requirements for generating units and plants. For dispersed generation systems in LV networks, the Technical Report IEC/TR 61000-3-15 is addressing gaps in the existing EMC standards making recommendations on the following aspects:

- harmonic emission;
- flicker and voltage fluctuation emission;
- DC injection;
- short and long duration over-voltages emission;
- switching frequency emission;
- immunity to voltage dips and short interruptions;
- immunity to frequency variation;
- immunity to harmonics and inter-harmonics;
- unbalance emission.

As next step in the standardization process, IEC/SC 77A plans to include, if necessary, specific requirements for generators. New standards to cover switching frequencies are under development, such as IEC 61000-4-19 on immunity to conducted, differential mode disturbances in the frequency range from 2 kHz to 150 kHz.

As long as specific tests for generators are not available, generic EMC standards, regarding immunity as well as emission, should be applied. The applicable standards, which in turn describe the test in accordance with basic standards (EN 61000-3, all parts, and EN 61000-4, all parts), are:

- Immunity: EN 61000-6-1 (residential, commercial and light-industrial environments);
- Emission: EN 61000-6-3 (residential, commercial and light-industrial environments): in this generic emission standard reference is made to e.g. the harmonics and voltage variation basic standards listed in Table 5.

Table 5 — Harmonics and flicker emission standards

Parameter	Micro-generator rating	Standard
Harmonics	≤ 16 A	EN 61000-3-2
Voltage fluctuations and flicker	≤ 16 A	EN 61000-3-3

In addition, the application of the requirements and tests described in IEC/TR 61000-3-15 is recommended, with the exception of those aspects already regulated by specific national rules.

Generating plants can also disturb mains signaling (ripple control or power line carrier systems). EMC requirements on inter-harmonics and on conducted disturbances in frequency range between 2 kHz and 150 kHz are under development. In countries where such communication systems are used, national requirement may apply.

4.8.2 DC injection

The generating unit shall not inject a direct current.

NOTE In general this requirement is fulfilled if the DC current during type testing is less than a set value.

5 Operation and safety of the micro-generator

5.1 General

The micro-generator shall operate safely over the entire designed and declared operating range.

The settings of (country-specific) field adjustable set-points shall be readable from the micro-generator, for example on a display panel, user interface, or via a communication port.

5.2 Safety

This European Standard does not cover the safety of DSO personnel or their contracted parties, as their safety is a combination of electrical conditions and working instructions.

General requirements for safety of persons at work in or near and operation of electrical installations are given in EN 50110 (all parts), also national regulations can be applicable.

5.3 Information plate

In absence of product specific standards (e.g. EN 50524) the following information shall appear on the micro-generator nameplate:

- manufacturer's name or trade mark;
- type designation or identification number, or any other means of identification making it possible to obtain relevant information from the manufacturer;
- nominal power;
- nominal voltage;
- nominal frequency;
- phases;
- active factor range or, if no active factor is adjustable, the minimal power factor .

This information shall be provided on a plate on or in the micro-generator and shall be copied in the user manual as well as other related documentation. In addition, a serial number may be added to the plate only.

This information could be part of the information plate of the entire micro-generator system.

All the information shall be given in the language and in accordance with the practice of the country in which the micro-generator is intended to be installed or alternatively in English language.

5.4 Labelling

A warning notice shall be placed in such a position that any person gaining access to live parts will be warned in advance of the need to isolate those live parts from all points of supply.

Special attention should be paid that the power supply, measuring circuits (sense lines) and other parts may not be isolated from the network when the switch of the interface protection is open.

As a minimum, warning labels shall be placed:

- on the switchboard (DSO panel and consumer unit) that has the micro-generator connected to it;
- on all switchboards in between the consumer unit and the micro-generator itself;
- on, or in the micro-generator itself;
- at all points of isolation for the micro-generator.

All the information shall be given in the language and in accordance with the practice of the country in which the micro-generator is intended to be installed.

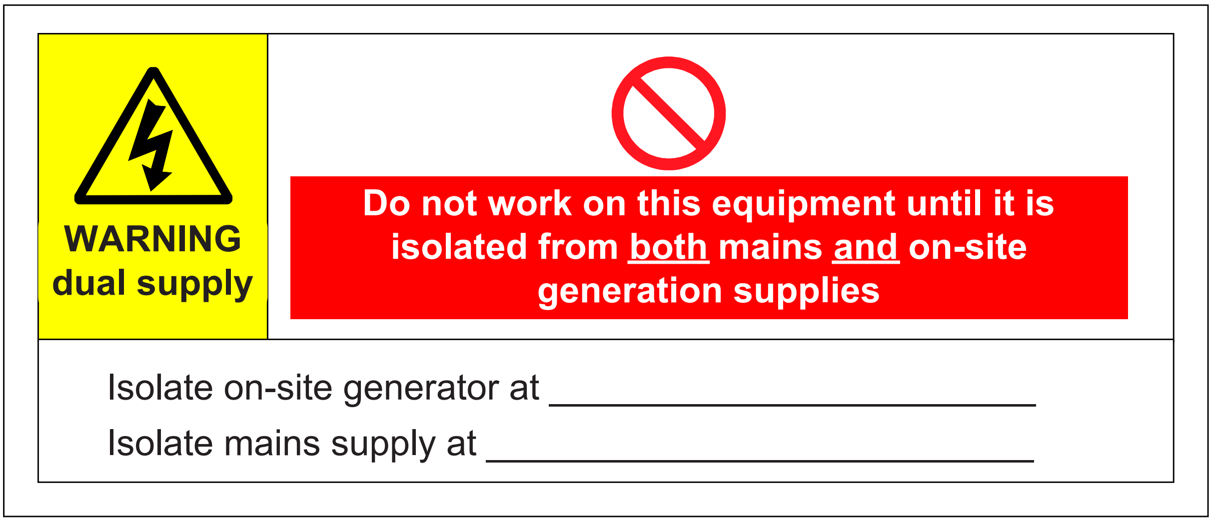

Figure 5 — Example of a warning label both for size and content

5.5 Maintenance and routine testing

The manufacturer shall provide a time frame for maintenance and routine testing.

NOTE Periodical routine testing of the interface protection system can be waived because of the provisions in 4.6.3.

The user is responsible for the proper maintenance and routine testing.

Maintenance and routine testing shall be carried out by qualified service technicians.

With respect to service technicians, additional national requirements shall be taken into account.

6 Commissioning

This European Standard applies to type-tested micro-generators.

NOTE An example of a test result sheet is given in Annex E.

The following conditions shall be met for the installation:

- the micro-generator (including the interface protection) shall fulfil the requirements of this standard and the other applicable standards;
- the manufacturer shall provide an installation instruction in accordance with this standard and national or regional requirements;
- access to the interface protection settings shall be tamper-proof;
- in the absence of product standards the micro-generator shall be type tested against the interface requirements of this standard;
- the installation shall be carried out by installers with recognised and approved qualification related to the fuels used, general electrical installations and a particular qualification relating to installation of micro-generators;
- the installer shall provide a single line diagram of the electricity generating facility. The single line diagram shall show the circuit breaker, the protections, the inverter, etc.

The user respective the installer should be aware that in addition to the DSO the energy supplier and/or the metering authority will need to be informed for contractual reasons.

Unless otherwise stated by national legislation or regulation, prior consent of the DSO is necessary.

Annex A
(informative)

National settings and requirements

A.1 General

In this European Standard reference is made to settings or conditions to be provided by the DSO, e.g.in case of:

- the settings for the power response to over-frequency (see 4.2.5);
- the settings of the interface protection (see 4.6.2);
- the reconnection conditions (see 4.6.3);
- the type of contribution to voltage control by reactive power (see 4.4.1)
- the protection of the settings from unpermitted interference (e.g. password or seal);
- the need of prior consent of the DSO (see Clause 6).

Moreover, respecting the legal framework, it is possible that, at a national level, more stringent requirements are defined or alternative options are chosen. This is the case for following topics:

- minimum time periods for operation in under-frequency (see 4.2.4);
- admissible active power reduction due to under-frequency (see 4.2.4);
- minimum time periods for operation in over-frequency (see 4.2.5);
- reference power when activating the power response to over-frequency (see 4.2.5).

Besides this at national level further requirements might be defined.

This annex provides information about these topics and / or the legal framework in different countries on date of publication of this European Standard.

Where possible, the micro-generator should be set in factory according to the settings for the place of installation.

A.2 AT – Austria

Settings shall be in compliance with the latest applicable technical rules and standards, which are on date of publication of this standard:

– Energie-Control Austria (www.e-control.at): TOR D4 V2.0:2008 Technische und organisatorische Regeln für Betreiber und Benutzer von Netzen. Teil D: Besondere technische Regeln. Hauptabschnitt D4: Parallelbetrieb von Erzeugungsanlagen mit Verteilernetzen, Version 2.0 2008;

– ÖVE/ÖNORM E 8001-4-712 Errichtung von elektrischen Anlagen mit Nennspannungen bis AC 1000 V und DC 1500 V – Teil 4-712: Photovoltaische Energieerzeugungsanlagen – Errichtungs- und Sicherheitsanforderungen, Version 2009-12-01;

– market rules and the general conditions of network operators.

The two documents are published by the Austrian Energy Regulator - Energie-Control GmbH (ECG) - on the website http://www.e-control.at.

On date of publication of this standard, the interface protection settings for photovoltaic installations connected to the LV (ÖVE/ÖNORM E 8001-4-712) are:

Parameter	Maximum clearance time s	Maximum trip setting
Over-voltage [a]	0,2	230 V + 15%
Under-voltage	0,2	230 V - 20%
Over-frequency [b]	0,2	51 Hz
Under-frequency [b]	0,2	47 Hz
LoM [c]	5	[c]
NOTE Voltage and frequency are referred to the micro-generator.		
[a] In order to ensure that the voltage remains within the limits, the running 10 min average of the voltage shall be monitored. The threshold shall be adjustable between +10 % and +15 %. In case of excess of the threshold the generator shall disconnect. [b] This function has to operate at least in the range of maximum trip settings of voltage. [c] LoM protection and test procedures have to be conform with ÖVE/ÖNORM E 8001-4-712.		

A.3 BE – Belgium

The national settings can be found on the website of Synergrid (www.synergrid.be) and more precisely in the Technical prescriptions CE10/11.

On date of publication of this standard, these settings are:

- Settings for **power reduction at over-frequency**

Parameter	Value
Threshold frequency	50,2 Hz
Droop	5% (*)
Intentional delay	Defined by DSO

(*)This Droop represents a gradient of 40% P_M /Hz

- **Protection settings**:

In case an automatic disconnection device is used:

Parameter	Trip setting
Over-voltage stage1 [a]	230 V + 10 % no delay
Over-voltage Stage2	230 V + 15 % no delay
Under-voltage	230 V – 20 % no delay
Over-frequency	51,5 Hz no delay
Under-frequency	47,5 Hz no delay
LoM	According to DIN V VDE V 0126-1-1
[a] Based on a 10 min average value.	

Alternative solutions are possible: see Technical Prescriptions CE10/11

- Settings for **automatic reconnection** after disconnection due to over-frequency:

Parameter	Value
Frequency range	47,5 Hz to 50,05 Hz
Voltage range	0,85 U_n to 1,10 U_n
Observation time	60 s
Gradient	10 % P_n/min

- The DSO **shall be informed** before connection of the micro-generator.

A.4 CY – Cyprus

Parameter	Clearance time s	Trip setting
Over-voltage	0,5	230 V + 10%
Under-voltage	0,5	230 V - 10%
Over-frequency	0,5	50 Hz + 4%
Under-frequency	0,5	50 Hz - 6%
LoM	0,5	[a]
[a] Based on ROCOF (Rate Of Change Of Frequency), trip value currently 0,6 Hz/s, final to be announced.		

A.5 CZ – Czech Republic

In compliance with “Operational rules for distribution networks” of the Distribution System Operators.

Parameter	Maximum clearance time s	Maximum trip setting
Over-voltage	0,2	230 V + 15%
Under-voltage	0,2	230 V - 15%
Over-frequency	0,5	52 Hz
Under-frequency	0,5	47,5 Hz

Different settings as above shall be approved by DSO.

Document “Operational rules for distribution networks” is published by the DSO’s of the Czech Republic – on their websites.

Settings for automatic reconnection shall be approved by DSO.

Prior to installation the DSO has to be requested for permission for the connection of the micro-generators.

A.6 DE – Germany

In Germany VDE-AR-N 4105 applies.

A.7 DK – Denmark

Parameter	Maximum disconnection time	Minimum relay operate time	Trip value [a]
Over voltage (stage 2) [b]	0,2 s	0,1 s	230 V + 13%
Over voltage (stage 1)	40 s	39 s	230 V + 10%
Under voltage (stage 1)	10 s	9 s	230 V – 10%
Over frequency	0,2 s	0,1 s	52 Hz
Under frequency	0,2 s	0,1 s	47,5 Hz
ROCOF [c]	0,2 s	0,1 s	2,5 Hz/s
	[a] All values are true 50 Hz RMS values. The micro-generator shall disconnect [d] if a parameter deviates more from its nominal value than the trip setting. A parameter shall not initiate a disconnection if it is between the nominal value and the trip setting. Tolerances on trip values: - voltage: ± 1 % of nominal voltage, - frequency: ± 20 mHz, - time: ± 10 %. [b] A stage 2 protection is required if the micro-generator can generate voltages in excess of 230 V + 13 %. [c] The use of phase shift relay as LoM detection is not allowed. [d] Disconnection of the micro-generator in response to an interface protection operation shall be achieved by the separation of mechanical contacts providing at least the equivalent of basic insulation.		

The activation of active power frequency response is not allowed without prior written consent by the relevant DNO/DSO.

A.8 EE – Estonia

National requirements:

The default settings of 4.6.2, Table 4 are applicable.

LoM protection shall use recognised techniques suitable for the distribution network protection. LoM protection shall be verified by test procedures which are in conformity with current standard Annex D or in compliance with other recognised document, e.g. VDE-AR-N 4105:2011. Detection of an isolated network and disconnection of the power generation system shall be completed in 5 s.

A.9 ES – Spain

National requirements:

In Spain (ES), the following Laws and Decrees deal with requirements for the connections to the public distribution network:

Ley 54/1997, Electricity Sector law	General rules for the interconnection of RES and CHP plants to the grid. Utilities are bound to buy the surplus of electricity generated by these installations and to pay for that energy higher price.
RD 1955/2000, Gives rules for transmission, distribution, commercialisation, supply and permission procedures or electric energy plants	It establishes the legal framework applicable to the activities of transmission, distribution, marketing and electricity supply.
RD 661/2007 Regulates the activity of electricity production in special regime.	Administrative and some technical rules for generation in special regime of any technology, power and voltage level. Partially superseded for small generation by RD 1699/2011.
RD 1699/2011 Regulates the connection of small generation	Administrative and technical rules for generation in special regime of any technology. Up to 100 kW in LV networks.
National grid-code or similar documents in ES (Spain)	
RD 842/2002, Spanish Low Voltage Code, part: ICT-BT 40, “Low voltage generating installations”	Complementary instruction (ICT) applicable to generating installations, namely installations aimed at the transformation of any kind of non-electric energy into electric energy.

Interfaces protection settings:

LV installations (up to 100 kW)

Parameter	**Clearance time** (maximum in seconds)	**Trip setting**
Over-voltage (Stage 2)	0,2	230 V + 15 %
Over-voltage (Stage 1)	1,5	230 V + 10 %
Under-voltage	1,5	230 V – 15 %
Over-frequency [a]	0,5	50,5 Hz
Under-frequency	3	48 Hz
[a] Different from most of MV generation and HV generation, which is 51 Hz.		

A.10 FI – Finland

Parameter	Clearance time s	Trip setting
Over-voltage	0,2	U_n + 10%
Under-voltage	0,2	U_n - 15%
Over-frequency	0,2	51,5 Hz
Under-frequency	0,2	47,5 Hz
LoM [a]	Maximum clearance time: 5 s	
[a] LoM protection shall use recognised techniques suitable for the distribution network protection. REMARK Isolation of the micro-generator shall be achieved by the separation of mechanical contacts. This mechanical device shall be a lockable isolation switch.		

Minimum time period for which a micro-generator shall be capable of operating when frequency is within limits 47,5 Hz -49 Hz and 51,0 Hz -51,5 Hz is 30 min.

Micro-generator shall operate normally while rate of change of frequency is under 2 Hz/s.

Micro-generator can be equipped with a capability to reduce active power output in response to a change in frequency above a certain frequency level. This capability is not mandatory.

A.11 FR – France

Requirements for connection of decentralised generation to the French low voltage distribution network are ruled by the applicable laws and regulations, and in particular by the following documents, or the documents that may overrule them due to change or update of laws or regulations:

- « Décret n° 2008-386 du 23 avril 2008 relatif aux prescriptions techniques générales de conception et de fonctionnement pour le raccordement d'installations de production aux réseaux publics d'électricité » ;
- « Arrêté du 23 avril 2008 relatif aux prescriptions techniques de conception et de fonctionnement pour le raccordement à un réseau public de distribution d'électricité en basse tension ou en moyenne tension d'une installation de production d'énergie électrique » ;
- « Guide Pratique UTE C 15-400, Raccordement des générateurs d'énergie électrique dans les installations alimentées par un réseau public de distribution » ;
- « Guide Pratique UTE C 15-712-1, Installations photovoltaïques raccordées au réseau public de distribution » ;
- « Documentation Technique de Référence d'ERDF », in particular « ERDF-NOI-RES_13E - Protections des installations de production raccordées au réseau public de distribution ».

A.12 GB – United Kingdom

The compulsory requirements for the connection of micro-generators in parallel with a GB public low-voltage distribution network can be found in the GB Distribution Code annex document - Engineering Recommendation ER G83 - *Recommendations for the Connection of Type Tested Small-scale Embedded Generators (Up to 16A per Phase) in Parallel with Low-Voltage Distribution Systems.*

In GB there is a legal requirement (under Electricity Safety, Quality and Continuity Regulations) for the installer to notify the DNO. In accordance with ESQCR 22(2)(c) the Installer shall ensure that the DNO is advised of the intention to use the micro-generator in parallel with the network no later than 28 d (inclusive of the day of commissioning), after commissioning the micro-generator.

Interface protection shall be installed which disconnects the micro-generator system from the DNO's distribution system when any parameter is outside of the settings shown in the table below.

G83/2 Protection settings

Protection function	Trip setting	Trip delay setting (time)
U/V stage 1	Vφ-n† - 13% = 200,1 V	2,5 s
U/V stage 2	Vφ-n† - 20% = 184 V	0,5 s
O/V stage 1	Vφ-n† + 14% = 262,2 V	1,0 s
O/V stage 2	Vφ-n† + 19% = 273,7 V[2)]	0,5 s
U/F stage 1	47,5 Hz	20 s
U/F stage 2	47 Hz	0,5 s
O/F stage 1	51,5 Hz	90 s
O/F stage 2	52 Hz	0,5 s
Loss of Mains* (Vector Shift)	12 degrees	0,0 s
Loss of Mains* (RoCoF)	0,2 Hz per second	0,0s

† A value of 230 V phase to neutral

* Other forms of Loss of Mains techniques may be utilised but the aggregate of the protection operating time, disconnection device operating time and trip delay setting shall not exceed 1,0 s. Under- and over-frequency protection is required in addition to LoM protection, not instead of.
Active methods for detecting LoM which inject current pulses into the distribution network are not accepted in Great Britain.

- In the United Kingdom it is necessary to provide a two stage for under- / over-voltage and frequency protection.
- The total disconnection time for voltage and frequency protection including the operating time of the disconnection device shall be the trip delay setting with a tolerance of, -0 s + 0,5s.
- For the avoidance of doubt voltage and frequency excursions lasting less than the trip delay setting shall not result in disconnection.
- The protection settings can be increased to 5,0 s for those micro-generator units that can withstand being energised from a source that is 180° out of phase with the micro-generator output.

DC Injection - The effects of, and therefore limits for, DC currents injected in the GB DNO's Distribution System is an area under current investigation by GB DNOs. Until these investigations are concluded the upper limit for DC injection is **0,25 % of AC current rating per phase.**

GB Frequency Range - 47,0 Hz – 52,0 Hz - The Frequency of the GB DNO's Distribution System shall be nominally 50 Hz and shall normally be controlled within the limits of 49,5 Hz - 50,5 Hz in accordance with principles outlined in the Electricity Safety, Quality and Continuity Regulations.

Automatic reconnection - With reference to 4.7.2, the interface protection shall ensure that feeding power to the distribution network will only commence, after the voltage and frequency on the distribution network have been within the limits of the interface protection settings for a minimum of 20 s for any generation system.

2) For grid surge voltages greater than 230 V +19 % which are present for periods of <0,5 s the micro-generator is permitted to reduce/cease exporting in order to protect the equipment.

Power reduction at over-frequency – GB does not implement power reduction at over-frequency and is therefore excluded from this requirement.

A.13 IE – Ireland

The national settings can be found on the website of ESB: (http://www.esb.ie/main/home/index.jsp) and more precisely:
DTIS-230206-BRL Mar 2009: Conditions Governing the Connection and Operation of Micro-generation

Parameter	Clearance time s	Trip setting
Over-voltage	0,5	230 V + 10%
Under-voltage	0,5	230 V - 10%
Over-frequency	0,5	50 Hz + 1%
Under-frequency	0,5	50 Hz - 4%
An explicit Loss of Mains functionality shall be included. Established methods such as, but not limited to, Rate of Change of Frequency, Vector Shift or Source Impedance Measurement may be used. Where Source Impedance is measured, this shall be achieved by purely passive means, Any implementation which involves the injection of pulses onto the distribution network, shall not be permitted.		
ROCOF (where used)	0,5	0,4 Hz/s
Vector Shift (where used)	0,5	6°

A.14 IT – Italy

Parameter	Maximum operate time s	Maximum trip setting
Over voltage 59.S1 (rms mean over 10 min according to EN 61000-4-30) with update of the value every 3 s	603	230 V + 10%
Over voltage 59.S2	0,20	230 V + 15%
Under voltage 27.S1 (1)	0,40	230 V -15%
Under voltage 27.S2 (2)	0,2	230 V – 60%
Over frequency 81>.S1 (3) (4) (5) (6)	0,1	50,5 Hz
Under frequency 81<.S1 (3) (4) (5) (6)	0,1	49,5 Hz
Over frequency 81>.S2 (3) (5)	1,0 (or 0,1)	51,5 Hz
Under frequency 81<.S2 (3) (5)	4,0 (or 0,1)	47,5 Hz
(1): in case of traditional generators (non inverter based) with nominal power of the generating plant not higher than 6 kW, it is possible to adopt a clearance time = 0 s		
(2): mandatory for inverter based generating plants with nominal power of the generating plant not higher than 6 kW		
(3): for voltage values $V \leq V_n$, frequency protection shall inhibit (no trip)		
(4): threshold enabled only with “external signal input” = “high” and “local command” = “high”		
(5): see following scheme and its operating description		
(6): for inverter based generating plants, through “local command” setting = “low”, these thresholds may be permanently excluded		

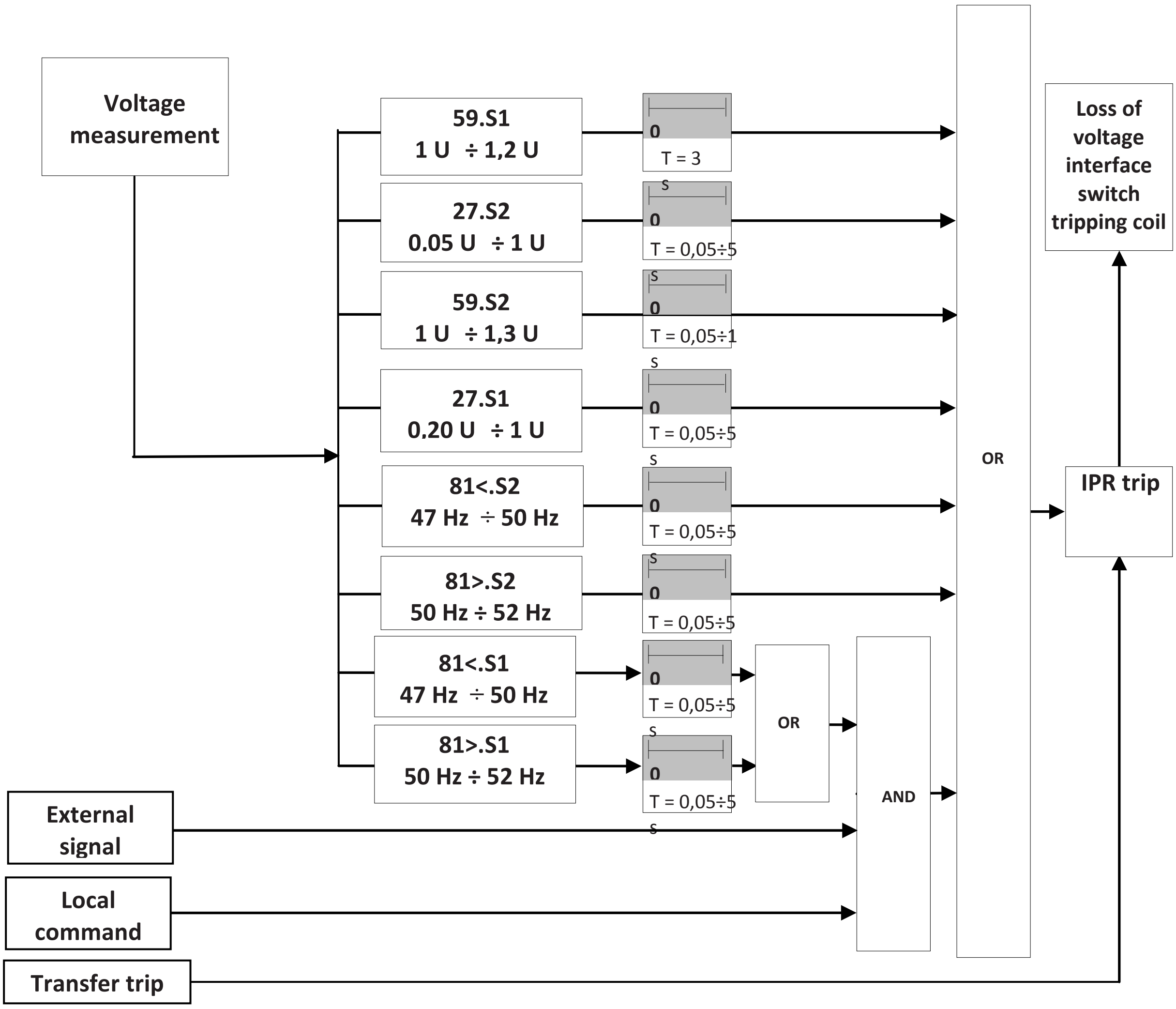

Figure A.1

Transfer trip signals via IEC 61850 protocol (protocol converter allowed) for:

- Telecommunication network available and operating (external signal input);
- Transfer trip command.

Stand alone operation mode (Interface protection relay operates only on the basis of local information, transient mode, due to absence of telecommunication network or particular temporary DSO's needs)

External signal setting: high (value "1"). Through local command settings:

- low (value "0"), Interface protection relay operates permanently in wide frequencies windows;
- high (value "1"), Interface protection relay operates permanently in narrow frequencies window.

In stand alone configuration, being frequency windows wide or narrow, their operate time is 100 ms.

Interface protection relay operation on the basis of local information and remotely transmitted commands/signals (definitive operation mode)

External signal settings:

- low (value "0"), in case of telecommunication network correctly operating. interface protection relay operates in wide frequencies window;

- high (value “1”), in case of telecommunication network temporary unavailable. interface protection relay operates temporary in narrow frequencies window;
- high (value “1”), in case of external command sent by DSO (for instance, in case of maintenance or fault detection on the feeder). interface protection relay operates temporary in narrow frequencies window.

Local command setting has to be permanently on “high” (value “1”).

In this operation mode operate time is 1 s for (81> .S2) and 4 s for (81< .S2).

Prior to installation the DSO has to be requested for permission for the connection of the micro-generator.

A.15 LV – Latvia

Parameter	Maximum disconnection time, s	Trip setting
Over voltage	1,5	230 V + 11 %
Under voltage	3	230 V – 11 %
Over frequency	0,5	50 Hz + 1 %
Under frequency	0,5	50 Hz – 1,6%
An explicit Loss of Mains functionality shall be included. Established methods such as, but not limited to, Rate of Change of Frequency, Vector Shift may be used. Any implementation which involves the injection of pulses onto the distribution network shall not be permitted.		
ROCOF (where used)	0,5	0,4 Hz/s
Vector Shift (where used)	0,5	8^{o}

Based of conflict with DNO requirements the Inform and fit procedure according to EN 50438 “Requirements for the connection of micro-generators in parallel with public low-voltage distribution networks” is not applied.

Requirements regarding connection of micro-generators in parallel with public low-voltage distribution networks are provided by the DNO.

On date of publication of this standard, the following national laws, regulations issued by the Cabinet of Ministers and regulations issued by Public Utilities Commission (PUC) deal with requirements for the micro-generator connections to the public distribution network:

- Elektroenerģijas tirgus likums, 05.05.2005 (Electricity Market Law)
- Ministru kabineta noteikumi Nr.883 “Noteikumi par atļaujām elektroenerģijas ražošanas jaudu palielināšanai vai jaunu ražošanas iekārtu ieviešanai” , 11.08.2009 (Cabinet Regulation No.883 Regulations regarding permits for increasing electricity production capacities or the introduction of new production equipment)
- Sabiedrisko pakalpojumu regulēšanas komisijas padomes lēmums Nr.1/6 “Sistēmas pieslēguma noteikumi elektroenerģijas ražotājiem”, 22.02.2012 (Regulations for a system connection for electricity producers)

National laws and regulations are available on the website: http://www.likumi.lv;

A.16 NL – The Netherlands

Parameter	Time s	Setting
Over-voltage	2,0	230 V + 10 %
Under-voltage [a]	2,0	230 V – 20 %
Over-frequency	2,0	50,0 Hz + 2 %
Under frequency	2,0	50,0 Hz – 4 %
LoM		
[a] For synchronous generators the disconnecting time is 0,2 s, or a shorter time depending on the Critical Short-circuit Time of the generator. In the Netherlands it is only necessary to provide a single stage for under/over-voltage and for frequency protection.		

A.17 NO – Norway

National requirements:

In Norway, the Regulation REG. N° 301 of 11 March 1999: "Regulations governing metering, settlement and coordinated action in connection with electricity trading and invoicing of network services." do not allow connection of a generator to the network without prior setting up of a new connection agreement with the DSO.

The default setting of 4.6.2, Table 4 are applicable excepted as follows:

– Footnote [a] for Norway:
  [a] Over-voltage – stage 1: 1 min mean value corresponding to Regulation 1557.

(national deviation due to regulation Reg. N° 1557 of 30 November 2004: Regulations relating to the quality of supply in the Norwegian power system).

A.18 PL – Poland

National requirements:

If no specific national settings for the Interface Settings are supplied by the Polish National Committee, the default settings in 4.6.2, Table 4 are applicable.

In Poland, the following regulatory text deals with general requirements for the connections to the public distribution network:

Rozporządzenie Ministra Gospodarki z dnia 4 maja 2007 r. w sprawie szczegółowych warunków funkcjonowania systemu elektroenergetycznego (Dz. U. z 2007 r. Nr 93, poz. 623) ze zmianami (Dz. U. z dnia 25 lutego 2008 r.) i (Dz. U. z dnia 9 września 2008 r.)

Decree of the Minister of Economy of May 4, 2007, concerning detailed conditions of power system operation (Journal of Laws May 29, 2007) with changes of February 25, 2008 and September 09, 2008

A.19 SI – Slovenia

Slovenian national rules for connection and operation of generators in the distribution network were officially announced in the *Uradni list RS (Official Gazzette of the Republic of Slovenia) No. 41/2011* and are published on the website of the SODO – Slovenian Electricity Distribution System Operator.

http://www.sodo.si/druzba_sodo/zakonodaja/sondo.

Interface protection settings in compliance with *Slovenian national rules for connection and operation of generators in the distribution network* are following:

Parameter	**Max clearance time** **(s)**	**Trip setting**
Over voltage (stage 2)	0,2	230 V + 11 % ... + 15 %
Over voltage (stage 1) [a]	1,5	230 V + 11 %
Under voltage (stage 1) [b]	1,5	230 V – 15 %
Under voltage (stage 2)	0,2	230 V – 15 % ... – 30 %
Over frequency [c]	0,2	51 Hz
Under frequency [c]	0,2	47 Hz
LoM [d]	- [d]	- [d]

a Over voltage (stage 1) protection is not required if the setting of over voltage (stage 2) is set to 230 V + 11 %.

b Under voltage (stage 1) protection is not required if the setting of under voltage (stage 2) is set to 230 V – 15 %.

c This function has to operate at least in the range of maximum trip settings of voltage.

d LoM protection is not required.

All other requirements including obligatory reactive power management are stated in the *Slovenian national rules for connection and operation of generators in the distribution network*.

A.20 SE – Sweden

Parameter	Clearance time s	Trip setting
Over-voltage (stage 2)	60	230 V + 11 %
Over-voltage (stage 1)	0,2	230 V + 15 %
Under-voltage (stage 1)	0,2	230 V – 15 %
Over-frequency	0,5	51 Hz
Under frequency	0,5	47 Hz
Loss of Mains (LoM)	0,15	

Inform and Fit procedure

Based on conflict with national legal requirements the Inform and Fit procedure according to EN 50438 “Requirements for the connection of micro-generators in parallel with public low-voltage distribution networks” is limited.

Reasons are found in the following Swedish laws and regulations:
- SFS 1997:857, in particular 3 kap 10 § and 8 kap 6 §;
- SFS 1999:716, in particular 4 §;

The Swedish laws SFS 1997:857 and SFS 1999:716 are issued by the Swedish parliament and can be found at http://www.lagrummet.se by using the search function.

The DSO is obliged to measure the electrical energy produced and distributed to the network according to SFS 1997:857 3 kap 10 §. Thus the DSO shall be informed before connection in order to determine if the energy meter is suitable to measure production as well as consumption. If not suitable, one needs to be installed.

An electricity supplier, who will begin to deliver electricity in a point of the network, shall immediately inform the DSO concerned according to SFS 1997:857 8 kap 6 §.

Annex B
(informative)

Loss of Mains and overall system security

Loss of Mains detection and overall system security entail conflicting requirements.

On the one hand, frequency is a common characteristic within an interconnected synchronous area. As it affects all connected generators at the same time, frequency related requirements aim to assure overall system security. Considering the share of distributed generation in the overall production, these generators have to be able to operate in a wide frequency range for a definite duration in order to avoid a massive disconnection. They shall as well be capable of participating actively in load frequency control due to a chosen response to frequency deviations.

On the other hand, frequency-dependent characteristics can be used to detect unintentional island situations in order to disconnect the generating units. This is essential to limit the risk of damages to equipment (in the producer's installations as well as in the distribution network) due to:

- (automatic) reclosing cycles 'causing' asynchronous reconnection; and
- violation of EN 50160.

Additionally frequency dependant characteristics allow for maintenance work after an intentional disconnection of a section of the distribution network.

If implemented without any precaution, the wide operational frequency range and the active response to frequency deviations will have a negative impact on the detection of unintentional islands using frequency-dependant characteristics. At present, reported islanding situations took place in moments in which load and generation were sufficiently balanced, which limits the probability of this kind of events. The use of active power response to frequency deviations in combination with a wider operational frequency range (and wide protection settings) will make a load-generation balance more likely. As a consequence, a stable unintentional island, especially in situations with production exceeding consumption may occur.

This standard identifies some approaches to combine the interests of overall system security and the detection of unintentional islanding:

- an intentional delay in the activation of the response to frequency deviation with the time needed for the island detection to operate (see 4.2.5); and
- the possible activation of a narrow frequency window (e.g. 49,8 Hz – 50,2 Hz) in the interface protection in case of a local event (Annex A).

Other possibilities to combine both interests and to partially counteract the negative impact on the detection of unintentional islanding and its consequences exist. Nevertheless they all have their limitations and drawbacks and cannot be implemented in a general way due to different constraints (technical, timing, economical, etc). Among other possibilities, some are listed here:

- other methods of islanding detection not based on frequency including transfer trip;
- voltage supervised reclosing;
- remote control of generators or loads, e.g. during maintenance works;
- multiphase earthing of the island.

Annex C
(informative)

Example notification sheets

C.1 General

Prior to installation the DSO has to be requested for permission for the connection of the micro-generator units using Form C.2, ‘Application for connection of micro-generators’.

In a few countries, a simplified procedure ("Inform and Fit") is allowed for installation of a single micro-generation unit.

Under Inform and Fit, the installation of a single micro-generator unit within a single customer’s installation can be connected in parallel with the public distribution network without the prior permission of the local DSO. The installer is to ensure that the local DSO is made aware of the micro-generator installation at or before the time of commissioning. In addition the installer shall provide the DSO with information on the installation, within 30 days of the micro-generator unit being commissioned.

NOTE The DSO and/or Energy Supplier and/or the metering authority might require contractual modifications of the existing connection agreement with the customer following the installation of the micro-generator.

In countries where Inform and Fit is allowed a form similar to C.2 can be used to notify the DSO of (rather than to apply for) a single micro-generation installation.

C.2 Application for connection of micro-generators

The application for the connection of micro-generators in parallel with the public distribution network – whether a single generating unit or a plant with multiple units at the same point of connection – comprises the submission of only one application form.

This information is to be provided to the DSO prior to the installation of micro-generators in order that the DSO can assess the potential impact that the connection will have on the network.

This notification form should be used for all micro-generator installations, i.e. single installations or installations that form part of a multiple installation.

Project details	
Site / project address (inc. post code)	
Telephone number	
Customer supply number(s) (if available)	
Distribution system operator	
Installer details	
Installer	
Accreditation / Qualification (if relevant)	
Address (inc. post code)	
Contact person	
Telephone number	
Fax number	
E-mail address	

Micro-generation details	
Number of Micro-generator	
Micro-generator location within the installation	
Micro-generation manufacturer / model type	
Micro-generation rating (kVA) and power factor	
Single or multi phase	
Micro-generator maximum peak short circuit current (A)	
Copy of system circuit diagram within the installation	
Earthing arrangements	
Site layout plan showing location of the micro-generators (if applicable)	
Type of prime mover and fuel source	
Serial number(s) of micro-generator(s)	
Electricity meter reading when micro-generation fitted (if more meters or more meter registers: give all readings)	
Meter registration number(s)	

Declaration to be completed by installer		
Comments		
I declare that this installation has been designed to comply with the manufacturer's requirements, instructions, and the relevant sections of the national wiring regulations and earthing requirements (HD 60364 – IEC 60364).		
Name:	Signature:	Date:

DSO comments – to be completed by DSO representative following application		
A representative of the DSO will wish to witness the commissioning		Yes / No
As a representative of the DSO, I give, in principle, permission for the connection of these micro-generators. If "no", see comments below		
Comments		
DSO	Contact	Date

C.3 Notification of micro-generator decommissioning

Site details		
Site address		
Telephone number		
Distribution system operator		
System owner		
Micro-generation details		
Micro-generation rating (kVA)		
Micro-generation manufacturer / model type		
Serial number of micro-generator		
Meter reading when micro-generator is removed		
Meter serial number		
Contractor details		
Contractor/Company		
Address		
Contact person		
Telephone number		
Fax number		
Declaration to be completed by contractor		
The micro-generator has been removed in compliance with the manufacturer's requirements (where specified), and the wiring of the premises has been reinstated to a satisfactory condition.		
Comments		
Name:	Signature:	Date:

Annex D
(informative)

Compliance type testing

D.1 General

At this time, with compliance type testing still under development, it is only possible for this annex to provide guidance for a methodology how a micro-generator could comply with the applicable requirements of this standard. Where alternative test methodologies are used these should be documented and where relevant referenced in the test report.

Even though many requirements of this standard are applicable to the micro-generating plant, the type testing is only applied to the micro-generator and the interface protection assuming that a plant of type-tested equipment will be compliant.

The default values in this annex have to be replaced by the specific national values in Annex A if supplied.

D.2 Type testing of the interface protection

D.2.1 Introduction

The interface protection, monitoring and control functions may be incorporated into the micro-generator control system, or may be fitted as discrete separate mounted devices. In both cases the micro-generator unit should be submitted for compliance testing with the interface protection either as a part of the appliance or as a separate control.

This annex defines the requirements for compliance testing of the interface protection.

An example of a type test result sheet is presented in Annex E.

D.2.2 General

The tests will verify that the operation of the micro-generator interface protection will result in a disconnection from the distribution network when the network parameters are exceeded or LoM occurs.

If the interface protection is considered as a dedicated device external to the micro-generator, only the operate time of the interface protection can be evaluated. In this case, the opening time of the interface switch shall be taken into account when evaluating the compliance with this European Standard.

Wherever possible the type verification testing of a particular micro-generator should be proved under normal conditions (as declared by the manufacturer and documented in the test report) of operation for that technology (unless otherwise stated). This will require that the chosen micro-generator interface protection is either already incorporated into the system controls or the discrete device is connected to the micro-generator for the LoM protection test.

Testing the voltage and frequency functions may be carried out either on the discrete protection device independently or on the micro-generator unit complete. In either case it will be necessary to verify that a protection operation will disconnect from the distribution network.

The manufacturer shall declare the ambient operating temperature range of the micro-generator and verify where appropriate that the interface protection control system operates satisfactory throughout this temperature range.

D.2.3 Over-/under-voltage

The operation of the micro-generator over-/under-voltage protection can be verified either under normal operating conditions (i.e. tripping the generator) or independently of the generator if suitable test terminals are provided.

Operation of the over-/under-voltage protection will be demonstrated for each of the voltage protection functions defined in 4.6.2.

The test can either be carried out for one specific setting or in general by testing two settings combining

- in the first test the threshold setting deviating the least from the nominal value with the longest disconnection time and
- in the second test the threshold deviating the most from the nominal value setting with the shortest disconnection time configurable.

In each test it shall be verified that the protection operation disconnects the micro-generator from the distribution network within the required disconnection time.

For each trip setting five tests shall be carried out.

a) Over voltage protection threshold $U_{th-high}$

1) Evaluation of the trip value:
Test: The applied voltage is varied from U_n up to $U_{th-high}$ + 2 % of U_n in steps of 0,5 % of U_n with a time duration per step exceeding the configured disconnection time.
Operate value: value of the applied voltage at which the protection function trips
Evaluation: the operate value shall be within ($U_{th-high}$ ± 1 % of U_n)

2) Evaluation of the disconnection time:
Test: application of a positive voltage step from U_n to the operate value + 5 % of U_n
Evaluation: The time elapsed between the application of the voltage step and the opening of the interface switch shall be within the range of the configured minimum operate and maximum disconnection time.

b) Under-voltage protection threshold U_{th-low}

1) Evaluation of the trip value:
Test: The applied voltage is varied from U_n down to U_{th-low} − 2 % of U_n in steps of 0,5 % of U_n with a time duration per step exceeding the configured disconnection time.
Operate value: value of the applied voltage at which the protection function trips
Evaluation: the operate value shall be within (U_{th-low} ± 1 % of U_n)

2) Evaluation of the disconnection time:
Test: application of a negative voltage step from U_n to the operate value − 5 % of U_n
Evaluation: The time elapsed between the application of the voltage step and the opening of the interface switch shall be within the range of the configured minimum operate and maximum disconnection time.

D.2.4 Over- /under-frequency

The operation of the micro-generator over-/under-frequency protection can be verified either under normal operating conditions (i.e. tripping the generator) or independently of the generator if suitable test terminals are provided.

Operation of the over-/under-frequency protection will be demonstrated for each of the frequency protection function defined in 4.6.2.

The test can either be carried out for one specific setting or in general by testing two settings combining:

- in the first test the threshold setting deviating the least from the nominal value with the longest disconnection time and
- in the second test the threshold deviating the most from the nominal value setting with the shortest disconnection time configurable.

In each test it shall be verified that the protection operation disconnects the micro-generator from the distribution network within the required disconnection time.

For each trip setting five tests shall be carried out.

a) Over-frequency protection threshold $f_{th\text{-}high}$:

1) Evaluation of the trip value:
Test: The applied frequency is varied from f_n up to $f_{th\text{-}high}$ +0,1 Hz in steps of 0,025 Hz with a time duration per step exceeding the configured disconnection time.
Operate value: value of the applied frequency at which the protection function trips
Evaluation: the operate value shall be within $f_{th\text{-}high}$ ± 0,05 Hz.

2) Evaluation of the disconnection time:
Test: application of a positive frequency step or ramp from f_n to the operate value +0,1 Hz
Evaluation: The time elapsed between the application of the frequency step respectively the applied ramp passes the operate value and the opening of the interface switch shall be within the range of the configured minimum operate and maximum disconnection time.

b) Under-frequency protection threshold $f_{th\text{-}low}$:

1) Evaluation of the trip value:
Test: The applied frequnecy is varied from f_n down to $f_{th\text{-}low}$ -0,1 Hz in steps of 0,025 Hz with a time duration per step exceeding the configured disconnection time.
Operate value: value of the applied frequency at which the protection function trips
Evaluation: the operate value shall be within $f_{th\text{-}low}$ ± 0,05 Hz.

2) Evaluation of the disconnection time
Test: application of a negative frequency step or ramp from f_n to the operate value -0,1 Hz
Evaluation: The time elapsed between the application of the frequency step respectively the applied ramp passes the operate value and the opening of the interface switch shall be within the range of the configured minimum operate and maximum disconnection time.

D.2.5 Loss of Mains (LoM) detection

D.2.5.1 General

In case of loss of supply from the distribution network, the LoM protection shall ensure that the micro-generator disconnects from the distribution network until all DSO protection operations have cleared and normal network supplies have been restored.

Examples of micro-generator protection systems suitable for LoM detection and protection include but are not limited to existing accepted techniques such as Rate of Change of Frequency (ROCOF) and Vector Shift.

D.2.5.2 Test on active LoM detection methods

For PV inverters EN 62116 applies, for all other technologies the following test environment applies.

Protection settings shall be applied that ensure disconnection within 2 s. To model the interaction between local load and multiple parallel connected micro-generator units the micro-generator unit under test shall be connected to a network combining two similar micro-generator units (EUT – equipment under test) and a variable load; the value of the load should have a power factor of 0,95 lagging. To facilitate the test for LoM there shall be a switch (52-3 in Figure D.1) placed between the distribution network and the combination of test load and micro-generator. The purpose of the test is to demonstrate the LoM protection equipment is able to recognise a change in load condition associated with a LoM event and to disconnect within the required time.

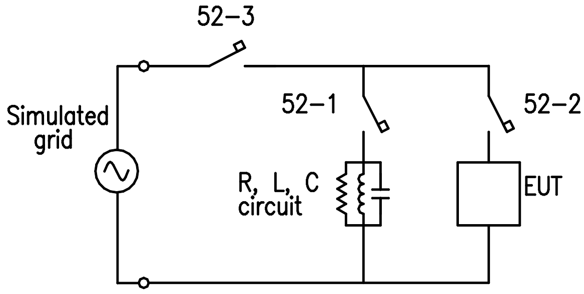

Figure D.1 — LoM test arrangement

Figure D.1 shows the test circuit to be connected between each phase of micro-generator (Equipment Under Test, EUT) and the neutral:

a) connect the EUT in accordance with the instructions of the manufacturer;

b) set all parameters of the EUT to the respective values of normal operation;

c) adjust the voltage and frequency of the simulated grid to the EUT's rated voltage ± 2 % and to EUT's nominal frequency (50Hz ± 0,1 Hz);

d) choose appropriate values for R, L and C so that the quality factor (Q_f) equals 1 ± 0,05 and resonance frequency is as close as possible to rated frequency;

   if the EUT output power factor is not 1, the EUT reactive power output shall be measured and taken into account when assessing Q_f;

e) close switches 52-1, 52-2 and 52-3, and adjust the EUT output power to its nominal value;

f) adjust R, L and C until the fundamental frequency current through 52-3 in each phase is 2 % of the EUT rated current or less;

g) trip 52-3 and record time duration between tripping of 52-3 and the tripping of the generator switch;

h) repeat the test, increasing the reactive power by 1 % each time. For each test, record the time duration between tripping of 52-3 and the tripping of the generator switch; stop testing when no further increase of this time occurs;

i) repeat steps a) to h) for no less than two intermediate operating conditions (e.g. 20 % and 50 % of nominal power) within the controllable range of the micro-generator.

D.3 Type testing of a micro-generator

D.3.1 Operating range

At least 2 tests shall be conducted, with the micro generator operating at nominal power connected to a grid simulator set as follows:

- Test 1: U = 0,85 Un; f = 47,5 Hz; P = 1,00 Sn; cosφ = 1
- Test 2: U = 1,1 Un; f = 51,5 Hz; P = 1,00 Sn; cosφ = 1

During the tests the interface protection has to be disabled.

(*) Operation at reduced power is allowed during test 1, equal to the maximum power that can be supplied on reaching the maximum output current limit ($P \geq 0,85\ S_n$).

(**) During the sequence of test 2, automatic adjustment to reduce power in the case of over-frequency shall be disabled.

In the case of photovoltaic micro-generators, the primary source can be simulated by a DC source provided that it is capable of continuously supplying the nominal power of the PV inverter.

During the test, frequency, voltage and the active power measured at the output terminals of the micro generator shall be recorded at a rate of at least 1 sample per second. The power supplied by the primary source shall be kept stable within ± 5 %*S_n compared to the value set for the entire duration of each test sequence.

D.3.2 Active power feed-in at under-frequency

D.3.2.1 Tests

Measurements are carried out at the following operating points:

a) nominal frequency ± 0,01 Hz;

b) a point between the nominal frequency –0,4 Hz to –0,5 Hz;

c) a point between the nominal frequency –2,4 Hz to –2,5 Hz.

The operating point b) and c) shall be maintained for at least 5 min.

Linear generators such as free piston Stirling machines are not tested according to Point c).

D.3.2.2 Assessment criterion

The test is regarded as passed if:

- the micro-generator does not disconnect from the network at the operating Points a) to c) when the network frequency is changed and
- the micro-generator does not reduce output energy at Point b) and
- the power reduction in point c) is less or equal to the allowed power reduction according to 4.2.4.

D.3.2.3 Test documentation

The following data shall be at least documented:

- variation of the network frequency with time;
- the measured active power with time.

D.3.3 Power response to over-frequency

D.3.3.1 General

The test serves to verify the active power reduction of the micro-generator at over-frequency. The test can either be carried out for on specific threshold frequency and droop setting or in general by testing two following settings:

- threshold frequency 50,2 Hz in combination with a droop of 12 % and
- threshold frequency 50,5 Hz in combination with a droop of 2 %.

The tests for providing evidence of the frequency dependent active power feed-in of the micro-generator shall be carried out on a network simulator.

Alternatively the tests can be carried out by one of the following methods:

- adjusting the input signals on the control unit of the micro-generator;
- adjusting the limit values (set values) in the control unit of the micro-generator if the manufacturer declares the full functionality of the micro-generator control and feed-in at all required operating frequencies (47,5 Hz to 51,5 Hz).

D.3.3.2 Tests

The following measuring points a) to g) shall be tested (refer to Figure D.2):

a) 50,00 Hz ± 0,01 Hz;

b) f_1+0,05 Hz ± 0,05 Hz;

c) 50,70 Hz ± 0,10 Hz;

d) 51,15 Hz ± 0,05 Hz;

e) 50,70 Hz ± 0,10 Hz;

f) f_1+0,05 Hz ± 0,05 Hz;

g) 50,00 Hz ± 0,01 Hz.

The same frequency deviations shall result when one of the alternative test procedures are applied by adjusting the limit values.

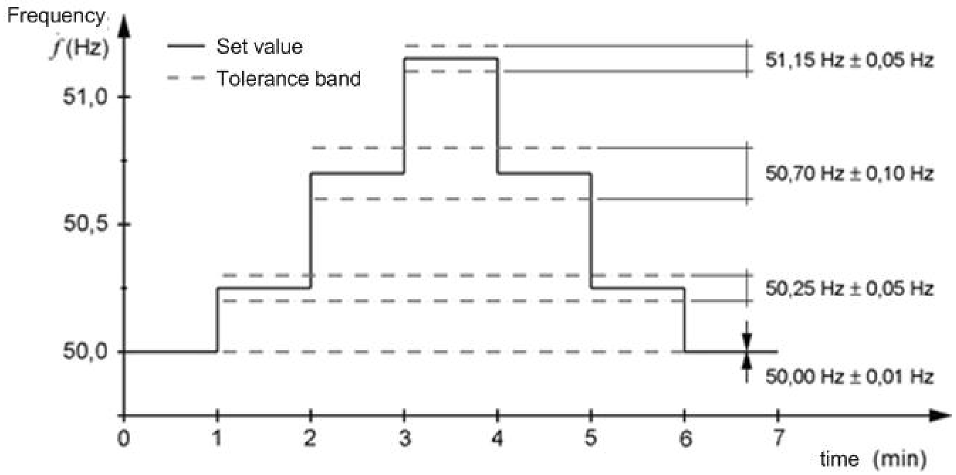

Figure D.2 — Example of testing the active power feed-in at over-frequency with f_1 = 50,2 Hz

D.3.3.3 Test procedure for adjustable and partly adjustable micro-generators

At f_1 the value of the currently generated active power P_M is "frozen".

The test is carried out at two power levels. First the test shall be started at a power of $>$ 80 % of nominal power and then a second time at a power of between 40 % nominal power and 60 % nominal power. During the second test, after the P_M has been frozen, the available active power value (depending on the available primary energy, heat generation, gas quality etc.) shall be increased to a value of $>$ 80 % nominal power and when the network frequency f_1 is underrun, the increase in the active power gradient shall be recorded.

Point g) shall be maintained until the micro-generator supplies the available active power output (depending on the primary energy available, heat generation, gas quality etc). During this period the power gradient (dP/dt) of the micro-generator shall be determined continuously. To determine the power gradient, a running 1 min mean value is calculated, whereby the 1 min mean value shall be calculated at least every second from the previous data. The active power gradient is calculated from the difference of the 1 min mean value at the time t[1] and the time $t_1 + 1$ min as follows:

$$(\Delta P / 1\,\text{min}) = (P_{t\,=\,t_1 + 1\,\text{min}} - P_{t\,=\,t_1}) / 1\,\text{min}$$

Hereby t_1 is the time from the beginning of the feed-in of active power of the micro-generator after reconnection until the end of the power limitation. With stepped control averaging starts at t_1 – 1 min.

The frequency and the active power at the micro-generator shall both be recorded. Evidence of the available active power output shall be given during the test.

D.3.3.4 Assessment criteria

The test is regarded as passed:

a) For adjustable micro-generators, if:

1) the active power drops between the previously mentioned measuring points b) and f) with the set gradient P_M per Hz with an increase in frequency or increases when the frequency decreases once more;
2) the maximum occurring active power gradient at point j) is less than the configured maximum active power per minute;
3) the active power value of the set value determined by the gradient characteristic curve does not deviate by more than + 10 % nominal power of the micro-generator;
4) the settling time is equal or below 2 s with an intentional delay set to zero.

b) For partly adjustable micro-generators, and non-adjustable micro-generators if:

1) they behave as described in a) inside their control range and
2) outside the control range, the power supplied when leaving the control range remains constant until disconnection. Disconnection shall occur at the latest at f_{max}.

The uniform distribution of the disconnection frequency in maximum increments of 0,1 Hz between the end of the control range (at least 50,2 Hz) and 51,5 Hz shall be ensured by the manufacturer's declaration.

D.3.3.5 Test documentation

The following data shall be at least documented:

- variation of the network frequency with time;
- the available active power output (depending on the primary energy available, heat generation, gas quality etc.);
- the measured active power with time;
- the maximum active power gradient.

D.3.4 Reactive power capability

D.3.4.1 Test of no controllable reactive power

This test applies to micro-generators with no controllable reactive power output.

For this test, the micro-generator supplies active power at steady state conditions to a busbar lower or equal to the reference impedance in IEC/TR 60725 via the power factor meter (pf) and a Variac of rating equal to or greater than the micro-generator as shown below. The micro-generator's pf should be in the range 0,95 lagging and 0,95 leading inclusive, for three test voltages (230 V – 8 %, 230 V and 230 V + 8 %), and for four active power outputs (20 %, 50 %, 75 %, and 100 % of nominal active power). For not controllable generators, the measurement shall be limited to full load power. For partly controllable generators, the measurement shall be limited to the power levels inside the controllable range. The test circuit is shown below:

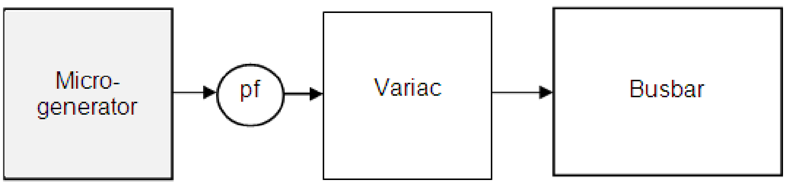

Figure D.3 — Power factor test arrangement

NOTE 1 For reasons of clarity the points of disconnection are not shown.

NOTE 2 Any other test arrangement is acceptable, provided the test meets the above requirements.

D.3.4.2 Test of controllable reactive power

D.3.4.2.1 Reactive power output capability

The test comprises the following steps:

- The micro-generator shall be set to maximum under excited operation possible for the micro-generator.
- The micro-generator shall be set to maximum over excited operation possible for the micro-generator.
- The micro-generator shall be operated with the settings above at 10 active power levels 0 %-10 %; 10 %-20 % ; ...; 90 %-100 % of the nominal output. 1 min-average-values shall be calculated using measurements at the basic frequency in a period of 200 ms.
- For each of the 10 active power levels, at least 3 under excited and 3 over excited reactive power levels shall be recorded. 1 min-average-values have to be calculated using voltage measurements at the basic frequency in a period of 200 ms.
- In addition to the measurements at maximum reactive power, the power levels shall be measured when setting the output reactive power to 0 (cosφ. = 1).

D.3.4.2.2 Assessment criterion

The test is considered to be passed when the value of the instantaneous power factor resulting in each of the measurement points between 20 % and 90 % of the nominal power is equal to or lower than 0,90 both in over excited and under excited operation.

D.3.4.2.3 Test documentation

Reactive and active power during the test shall be documented both in tabular and graphical form. The maximum reactive power capability input (Q_{min}) and output (Q_{max}) resulting from the above measurement sequence including Q=0 shall be documented in tabular form. For each level of active power output between 0 % and 100 % of the nominal power, the corresponding level of reactive power exchange expressed both as an absolute value Q and in terms of cos φ has to be shown.

D.3.4.2.4 Reactive power output according to an assigned level

The micro-generator shall help to control the network voltage. The purpose of the test is to check the capacity of the micro-generator's control system to execute the command to set the level of reactive power within the maximum capability limits both for under excited and over excited operation and to check the precision of the setting.

In the absence of an exchange protocol for reactive power settings, the manufacturer has the faculty to establish the procedures with which the commands for the reactive power take-off point are transmitted, both with regard to the physical signal (analogue, on serial protocol, etc.) and for the chosen setting parameter (setting according to an absolute reactive power value Q, or as the value of cos φ).

D.3.4.2.5 Procedures for performing tests and recording results (Q adjustment)

- Set the primary source so that the micro-generator supplies approximately 50 % of the nominal active power Pn.
- Use the method and the adjustment parameter specified by the manufacturer, change the reactive power supplied by the micro-generator, passing from a set value close to the maximum over excited directly to zero (Q = 0), and then from zero to a set value close to the maximum under excited value.
- For each set point, at least 3 values shall be recorded after the end of all transient effects, as 1-min-average value calculated on the basis of the measurements at basic frequency in a period of 200 ms.

D.3.4.2.6 Assessment criterion

The test is passed if the deviation of the 3 values measured for each set point to the set value is $\Delta Q \leq \pm 5$ % of the nominal active power of the micro-generator.

D.3.4.2.7 Test documentation

Reactive power during the test shall be documented both in tabular and graphical form.

D.3.5 Voltage control by active power

Under consideration.

D.3.6 Connection and starting to generate electrical power

D.3.6.1 General

These tests serve to provide evidence of compliance with the specifications of 4.7.

Connection and synchronisation are carried out or monitored by at least one suitable device. This device can be implemented in the control unit of the micro generator or in the interface protection as dedicated device.

– The manufacturer shall provide the test laboratory with a document stating which functions are implemented in which component.
– When the micro generator is not connected, the test is carried out by changing the set nominal frequency and nominal voltage in the control unit. Alternatively other processes such as a network simulator or test bench testing can be used for verification.

D.3.6.2 Connection after trip of interface protection

After the interface protection has been triggered, it shall be examined whether the system can only be connected within the tolerance ranges defined according to 4.7.2 and after the voltage and frequency remain within the tolerance ranges for at least the observation time according to 4.7.2.

NOTE The measurement tolerances of the interface protection are taken into consideration in the following sequence.

The test can either be carried out for one specific setting or in general by testing two settings combining in the first test the lowest threshold setting with the fastest connection time and in the second test the highest threshold setting with the slowest connection time configurable.

The test sequence below is configured for the default setting according to 4.7.2. In case of differing settings, the sequence has to be altered accordingly. Before the sequence and after each connection a trip of the interface protection shall be initiated.

Sequence for test after trip of interface protection (with actual frequency f_{act} and actual Voltage U_{act}):

a) $f_{act} < 47{,}45$ Hz: no reconnection permitted;

b) switch to $f_{act} \geq 47{,}45$ Hz: reconnection is permitted 60 s after switch to new frequency;

c) $f_{act} > 50{,}10$ Hz: no reconnection permitted;

d) switch to $f_{act} \leq 50{,}10$ Hz: reconnection is permitted 60 s after switch to new frequency;

e) $U_{act} < 0{,}84\ U_n$: no reconnection permitted;

f) switch to $U_{act} \geq 0{,}84\ U_n$: reconnection is permitted 60 s after switch to new voltage;

g) $U_{act} > 1{,}11\ U_n$: no reconnection permitted;

h) switch to $U_{act} \leq 1{,}11\ U_n$: reconnection is permitted 60 s after switch to new voltage.

At least one point of operation has to be operated until the power generation of the micro generator is stable. To determine the power gradient, a running 1 min mean value is calculated, whereby the 1 min mean value shall be calculated at least every second from the previous data. The active power gradient is calculated from the difference of the 1 min mean value at the time t_1 and the time $t_1 + 1$ min as follows:

$$(\Delta P / 1\,\text{min}) = (P_{t\,=\,t_1+1\,\text{min}} - P_{t\,=\,t_1}) / 1\,\text{min}$$

Hereby t_1 is the time from the beginning of the generation of electrical power of the micro-generator until the end of the power limitation. In case of stepped control the averaging starts at t_1 – 1 min.

D.3.6.3 Start of generating electrical power

After the stop of generating electrical power due to operational reasons of the micro generator, it shall be examined whether the system can only start generating power within the tolerance ranges defined according to 4.7.3 and after the voltage and frequency remain within the tolerance ranges for at least the observation time according to 4.7.3.The test can either be carried out for one specific setting or in general by testing two settings combining in the first test the lowest threshold setting with the fastest connection time and in the second test the highest threshold setting with the slowest connection time configurable.

The test sequence below is configured for the default setting according to 4.7.2. In case of differing settings, the sequence has to be altered accordingly. Before the sequence and after each start of generating electrical power a stop of production has to be initiated e.g. by reducing the primary energy source to zero power.

NOTE The measurement tolerances of the interface protection are taken into consideration in the following sequence.

Sequence for test for starting to generate electrical power:

a) $f_{act} < 47,45$ Hz: no starting permitted;

b) Switch to $f_{act} \geq 47,45$ Hz: starting is permitted 60 s after switch to new frequency;

c) $f_{act} > 50,15$ Hz: no starting permitted;

d) Switch to $f_{act} \leq 50,15$ Hz: starting is permitted 60 s after switch to new frequency;

e) $U_{act} < 0,84\ U_n$: no starting permitted;

f) Switch to $U_{act} \geq 0,84\ U_n$: starting is permitted 60 s after switch to new voltage;

g) $U_{act} > 1,11\ U_n$: no starting permitted;

h) Switch to $U_{act} \leq 1,11\ U_n$: starting is permitted 60 s after switch to new voltage.

At least one point of operation has to be operated until the power generation of the micro generator is stable. To determine the power gradient, a running 1 min mean value is calculated, whereby the 1 min mean value shall be calculated at least every second from the previous data. The active power gradient is calculated from the difference of the 1 min mean value at the time t_1 and the time $t_1 + 1$ min as follows:

$$(\Delta P / 1\,\text{min}) = (P_{t\,=\,t_1 + 1\,\text{min}} - P_{t\,=\,t_1}) / 1\,\text{min}$$

Hereby t_1 is the time from the beginning of the generation of electrical power of the micro-generator until the end of the power limitation. In case of stepped control the averaging starts at t_1 – 1 min.

D.3.6.4 Assessment criteria

The test is considered passed if:

a) the micro generator connects respectively starts generating electrical power only in the permitted range of voltage and frequency and

b) for adjustable micro generators the maximum occurring active power gradient after connection respectively start generating electrical power is less than the configured maximum active power per minute and

c) for non or partly adjustable generators the connection after trip of the interface protection is delayed by a randomised value between 1 min and 10 min.

D.3.7 Short-circuit current contribution

The micro-generator short-circuit parameters shall be determined by means of a short-circuit test carried out in a similar manner to that for larger alternators as described in EN 60034 series.

For electronic inverters, manufacturers shall declare the short circuit contribution.

D.3.8 Harmonic current emission

Manufacturers to declare their test procedure to demonstrate compliance with the emission limits of class A of EN 61000-3-2.

D.3.9 Voltage fluctuations and flicker

Manufacturers to declare their test procedure to demonstrate compliance with the emission limits of EN 61000-3-3.

D.3.10 DC injection

D.3.10.1 General

This test is only relevant for inverter-based systems without output transformers.

For this test, the micro-generator shall be operated in parallel with a voltage source meeting the requirements set for the voltage source in EN 61000-3-2:2006, Annex A in terms of voltage level and harmonic content. The DC component can be measured by one of the following two methods:

- the average of the current samples (preferred);
- root mean square of frequencies components below 1 Hz.

The DC component level shall be measured with an observation period large enough to ensure repeatability. This is considered to be met for an observation time of 1 min.

D.3.10.2 Test

The DC component shall be measured under steady-state conditions for the following power levels: 20 %, 50 %, 75 %, and 100 % of nominal power with a tolerance of ± 5 % of nominal power and as far as adjustable for the tested micro-generator.

D.3.10.3 Acceptance criteria

This test is passed if the DC current in the test above is lower than 0,5 % of nominal current or 20 mA whatever is the higher value.

Annex E
(informative)

Example test results sheet

E.1 General details

E.1.1 Micro-generator details

MICRO-GENERATOR Type reference		
Maximum continuous rating [3)]		
Manufacturer	Tel	Address
	Fax	
Technical file reference No.		

E.1.2 Test house details

Name and address of test house	
Telephone number	
Facsimile number	
E-mail address	

E.1.3 Test details

Date of test	
Name of test engineer	
Signature of test engineer	
Test location (if different from above)	

3) The full load electrical output of the micro-generators minus the appliance's own consumption.

E.2 Type testing of the interface protection

E.2.1 General

If the interface protection is considered as a dedicated device external to the micro-generator, only the operate time of the interface protection can be evaluated. In this case, the opening time of the interface switch shall be taken into account when evaluating the compliance with this European Standard.

E.2.2 Over-/under-frequency tests

	Over-frequency		**Under-frequency**	
Parameter	Frequency	Disconnection time	Frequency	Disconnection time
Protection limit (from Table 4 or Annex A)	…… Hz	…… s	…… Hz	…… s
Actual setting (as applied to interface protection)				
Trip value (test result)				

E.2.3 Over-/under-voltage tests (single stage protection)

	Over-voltage		**Under-voltage**	
Parameter	Voltage	Disconnection time	Voltage	Disconnection time
Protection limit (from Table 4 or Annex A)	…… V	…… s	…… V	…… s
Actual setting (as applied to interface protection)				
Trip value (test result)				

E.2.4 LoM test

Method used			
Output power level [a]	Min.	Medium	Max.
Trip setting clearance time			
Trip value clearance time			
[a] Indicative values are shown for minimum, medium and maximum power levels.			

E.3 Type testing of a micro-generator

E.3.1 Operating Range

Test sequence	Voltage	Frequency	Output power	Primary power source
Test 1				
Test 2				

E.3.2 Active power at under-frequency

Test sequence	Output Power	Frequency	Primary power source
Test a)			
Test b)			
Test c)			

E.3.3 Power response to over-frequency

Test sequence at power level >80%	Output Power	Frequency	Primary Power source	Power gradient
Step a)				-
Step b)				-
Step c)				-
Step d)				-
Step e)				-
Step f)				-
Step g)				

Test sequence at power level 40%-60%	Output Power	Frequency	Primary Power source	Power gradient
Step a)				-
Step b)				-
Step c)				-
Step d)				-
Step e)				-
Step f)				-
Step g)				

E.3.4 Reactive power

E.3.4.1 Uncontrollable reactive power

	Power factor		
Limit	+ 0,95 - 0,95 at three voltage levels and four power levels		
	210 V	230 V	250 V
20% of nominal active power			
50% of nominal active power			
75% of nominal active power			
100% of nominal active power			

E.3.4.2 Controllable reactive power

Reactive power output capability
Plot of P over Q of all measured points

Test sequence start of generation	**Output power**	**Set reactive power**	**Measured reactive power**	**Tolerance**

E.3.5 Connection and starting to generate electrical power

Test sequence after trip	connection	connection allowed	Primary power source	Power gradient after connection
Step a)		No		
Step b)		Yes		
Step c)		No		
Step d)		Yes		
Step e)		No		
Step f)		Yes		
Step g)		No		
Step h)		Yes		

NOTE 1 It is sufficient to evaluate the power gradient after connection only at one test out of b), d), f), h).

Test sequence start of generation	connection	connection allowed	Primary power source	Power gradient after connection
Step a)		No		
Step b)		Yes		
Step c)		No		
Step d)		Yes		
Step e)		No		
Step f)		Yes		
Step g)		No		
Step h)		Yes		

NOTE 2 It is sufficient to evaluate the power gradient after connection only at one test out of b), d), f), h).

E.3.6 Short-circuit current contribution

E.3.6.1 Short-circuit current at micro-generator terminals

Short-circuit applied to micro-generator at normal running condition 0 - 2,0 s plot

E.3.6.2 Short-circuit current parameters

Parameter	Symbol	Value 1	Value 2	Value 3	Value 4	Value 5
Peak short-circuit current	i_p					
Initial value of aperiodic component	A					
Initial symmetrical short-circuit current	I_k					
Decaying (aperiodic) component of short-circuit current	i_{DC}					
Reactance/Resistance ratio of source	$^X/_R$					

E.3.7 Power quality

Harmonic current emission											
	Maximum permissible harmonic current as per EN 61000-3-2, Class A										
	Odd harmonics							Even harmonics			
Harmonic order n	3	5	7	9	11	13	15 ≤ n ≤ 39	2	4	6	8 ≤ n ≤ 40
Limit	2,30	1,14	0,77	0,40	0,33	0,21	0,15 (15/n)	1,08	0,43	0,30	0,23 (8/n)
Test value											

Voltage fluctuations and flicker					
	Maximum permissible flicker and voltage fluctuation as per EN 61000-3-3				
Value	P_{st}	P_{lt}	d(t) – 500ms	d_c	d_{max}
Limit	1,0	0,65	3,3%	3,3%	4%
Test value					

E.4 Comments

Annex F
(informative)

Commissioning

F.1 Installation

The micro-generator shall be installed in accordance with all of the following requirements:

- this standard;
- HD 60364 series;
- national regulations;
- the manufacturer's installation instructions;
- technical requirements of the DSO (e.g. grid codes).

F.2 Notification procedure

F.2.1 Ordinary procedure

Unless otherwise stated by national legislation or regulation, it is necessary for the installer to obtain the prior approval of the local DSO. The DSO will need to assess the impact that the connection may have on the Network and specify conditions for connection. The initial application will need to be in a format similar to that shown in C.2. The confirmation of commissioning will need to be made within 30 days of commissioning, using a format similar to that shown in C.2.

The DSO may request the type-test information pro-forma when the application for connection pro-forma is submitted if they do not have previous records. The installer shall supply a copy within 30 working days of the request.

F.2.2 Inform and Fit for a single installation

See informative Annex C.

Annex G
(normative)

Countries allowing extension of the scope > 16 A

G.1 General

In some countries there is a national deviation to extend the scope of this standard for equipment rated greater than 16 A. These countries are listed in this annex.

Whenever the scope is extended to equipment rated greater than 16 A additional standards could be applicable.

G.2 CY – Cyprus

The scope of this standard is extended for generation rated up to and including 25 A per phase. In terms of rated power this refers to 5,75 kVA for a single phase equipment and 17,3 kVA for three phase equipment.

G.3 FI – Finland

The scope of this standard is extended to a rated power of up to 50 kVA for three phase equipment.

G.4 IE – Ireland

The scope of this standard is extended to 25 A at low voltage, when the distribution network connection is single-phase.

The scope of this standard remains unchanged at 16 A at low voltage, when the distribution network connection is three-phase.

Annex H
(informative)

Abbreviations

CEN	Comité Européen de Normalisation
CENELEC	Comité Européen de Normalisation ELECtrotechnique
CHP	Combined Heat and Power
CLC	CENELEC
DSO	distribution system operator
EN	European Standard
IEC	International Electrotechnical Commission
EMC	ElectroMagnetic Compatibility
HD	Harmonisation Document (CENELEC)
ISO	International Organization for Standardization
LoM	Loss of Mains
LV	low voltage
ROCOF	Rate Of Change Of Frequency
TC	Technical Committee (standardization)
WG	Working Group

Annex I
(informative)

A-deviations

A-deviation: National deviation due to regulations, the alteration of which is for the time being outside the competence of the CENELEC national member.

This European Standard does not fall under any Directive of the EC.

In the relevant CENELEC countries these A-deviations are valid instead of the provisions of the European Standard until they have been removed.

<u>Clause</u>	<u>Deviation</u>
General	**Italy** (Italian law No. 239 of August 23rd, 2004, modified by the government decree No. 20 of February 8th, 2007, Clause 11, Paragraph d)) The above Italian law applies to all micro-generators which are in parallel to LV networks and states: *Within six months from the date of coming into effect of this law the Ministero delle Attività Produttive in agreement with the Ministero dell'Ambiente e della Protezione del Territorio and the Ministero degli Interni will enact a specific Decree concerning the homologation of micro-generation systems. This Decree will fix the emission and noise limits and safety criteria for micro-generation systems.*

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[5] EN 61000 (all parts), *Electromagnetic compatibility (EMC) (IEC 61000 series)*

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