SLOVENSKI STANDARD
SIST EN 62116:2011

01-maj-2011

Preskusni postopki za ukrepe proti otočnemu delovanju fotonapetostnih razsmernikov, povezanih na omrežje (IEC 62116:2008, spremenjen)

Test procedure of islanding prevention measures for utility - interconnected photovoltaic inverters

Prüfverfahren für Maßnahmen zur Verhinderung der Inselbildung für Versorgungsunternehmen in Wechselwirkung mit Photovoltaik - Wechselrichtern

Procédure d'essai des mesures de prévention contre l'ilotage pour onduleurs photovoltaïques interconnectés au réseau public

Ta slovenski standard je istoveten z: EN 62116:2011

ICS:

27.160	Sončna energija	Solar energy engineering

SIST EN 62116:2011 **en,fr,de**

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 62116

March 2011

ICS 27.160

English version

Test procedure of islanding prevention measures for utility-interconnected photovoltaic inverters
(IEC 62116:2008, modified)

Procédure d'essai des mesures de prévention contre l'ilotage pour onduleurs photovoltaïques interconnectés au réseau public
(CEI 62116:2008, modifiée)

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Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat 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 Central Secretariat has the same status as the official versions.

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CENELEC

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

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Ref. No. EN 62116:2011 E

Foreword

This European Standard consists of the text of the International Standard IEC 62116:2008 together with common modifications prepared by the Technical Committee CENELEC TC 82, Solar photovoltaic energy systems.

The text of the draft was submitted to the formal vote (see BT decision D136/C054) and was accepted by CENELEC as EN 62116 on 2011-01-02.

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

The following dates were fixed:

– latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2012-01-02
– latest date by which the national standards conflicting with the EN have to be withdrawn	(dow)	2014-01-02

This European Standard consists of IEC 62116:2008 with some common modifications that have been developed within CLC/TC 82 and are identified in red and/or by a vertical line in the left margin of the text.

The scope of the common modifications is to add more detailed information on the application of the test procedure of islanding prevention measures.

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Contents

Introduction

Islanding is a condition in which a portion of an electric power grid, containing both load and generation, is isolated from the remainder of the electric power grid. This situation is one with which electric power providers (utilities) must regularly contend. When an island is created purposely by the controlling utility — to isolate large sections of the utility grid, for example — it is called an intentional island. Conversely, an unintentional island can be created when a segment of the utility grid containing only customer-owned generation and load is isolated from the utility control.

Normally, the customer-owned generation is required to sense the absence of utility-controlled generation and cease energizing the grid. However, when the generation and load within the segment are well balanced prior to the isolation event, the utility is providing little power to the grid segment, thus making it difficult to detect when the isolation occurs. Damage can occur to customer equipment if the generation in the island, no longer under utility control, operates outside of normal voltage and frequency conditions. Customer and utility equipment can be damaged if the main grid recloses into the island out of synchronization. Energized lines within the island present a shock hazard to unsuspecting utility line-workers and network users who think the lines and their equipment are dead.

The PV Industry has pioneered the development of islanding detection and prevention measures. To satisfy the concerns of electric power providers, commercially-available utility-interconnected PV inverters have implemented a variety of islanding detection and prevention (also called anti-islanding) techniques. The industry has also developed a test procedure to demonstrate the efficiency of these anti-islanding techniques; that procedure is the subject of this document.

This standard provides a consensus test procedure to evaluate the efficiency of islanding prevention measures used by the power conditioner of utility-interconnected PV systems. Note that while this document specifically addresses inverters for photovoltaic systems, with some modifications the setup and procedure may also be used to evaluate inverters used with other generation sources or to evaluate separate anti-islanding devices intended for use in conjunction with PV inverters or other generation sources acting as or supplementing the anti-islanding feature of those sources.

Inverters and other devices meeting the requirements of this document can be considered non-islanding, meaning that under reasonable conditions, the device will detect island conditions and cease to energize the public electric power grid.

1 Scope and object

The purpose of this European Standard is to provide a test procedure to evaluate the performance of islanding prevention measures used with utility-interconnected PV systems.

This standard does not specify settings parameters (voltage and frequency trip magnitude and trip time) nor pass/fail criteria, because the EN 50438 and/or National standards and/or grid codes should be taken into account for this purpose.

This standard describes a guideline for testing the performance of automatic islanding prevention measures installed in or with single or multi-phase utility interactive PV inverters connected to the utility grid. The test procedure and criteria described are minimum requirements that will allow repeatability. Additional requirements or more stringent criteria may be specified if demonstrable risk can be shown. Inverters and other devices meeting the requirements of this standard are considered non-islanding as defined in CLC/TS 61836.

This standard may be applied to other types of utility-interconnected systems (e.g. inverter-based microturbine and fuel cells, induction and synchronous machines). However, technical review may be necessary for other than inverter-based PV systems.

Alternative testing procedures to evaluate the performance of islanding prevention may be allowed by national standards and/or grid codes.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 61727, *Photovoltaic (PV) systems – Characteristics of the utility interface* (IEC 61727)

CLC/TS 61836, *Solar photovoltaic energy systems – Terms, definitions and symbols* (IEC/TS 61836)

EN 50438, *Requirements for the connection of micro-generators in parallel with public low-voltage distribution networks*

3 Terms and definitions

For the purposes of this document, the terms and definitions of CLC/TS 61836 apply as well as the following.

3.1
PV array simulator
DC power source used to simulate PV array output

3.2
EUT (Equipment Under Test)
EUT indicates the inverter or anti-islanding device on which these tests are performed

3.3
MPPT (Maximum Power Point Tracking)
MPPT is a PV array control strategy used to maximize the output of the system under the prevailing conditions

3.4
island
a state in which a portion of the electric utility grid, containing load and generation, continues to operate isolated from the rest of the grid. The generation and loads may be any combination of customer-owned and utility-owned.

3.5
intentional island
an island that is intentionally created, usually to restore or maintain power to a section of the utility grid affected by a fault. The generation and loads may be any combination of customer-owned and utility-owned, but there is an implicit or explicit agreement between the controlling utility and the operators of customer-owned generation for this situation.

3.6
quality factor, Q_f
a measure of the strength of resonance of the islanding test load.

NOTE 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

On a power system with active power, P, and reactive powers, Q_L, for inductive load, and Q_C for capacitive load, Q_f can be determined by

$$Q_f = (1/P)\sqrt{|Q_L| \cdot |Q_C|}$$

where

P is active power, in W

Q_L is inductive load, in VAr

Q_C is capacitive load, in VAr

3.7
run-on time, t_R
the amount of time that an unintentional island condition exists. Run-on time is defined as the interval between the opening of the switch S1 (Figure 1) and the cessation of EUT output current.

3.8
stopping signal
a signal provided by the inverter indicating it has ceased energizing its utility grid-connected output terminals (See Annex C)

3.9
unintentional island
an islanding condition in which the generation within the island that is supposed to cease energizing the utility grid instead continues to energize the utility grid

4 Testing circuit

The testing circuit shown in Figure 1 shall be employed. Similar circuits shall be used for three-phase output.

Parameters to be measured are shown in Table 1 and Figure 1. Parameters to be recorded in the test report are discussed in Clause 7.

Table 1 – Parameters to be measured in real time

Parameter	Symbol	Units
EUT DC input [a,b]		
DC voltage	V_{dc}	V
DC current	I_{dc}	A
DC power	P_{dc}	W
Irradiance [c]	G	W/m²
EUT AC output		
AC voltage [b, d, e]	V_{EUT}	V
AC current [b, d, e]	I_{EUT}	A
Active power [b]	P_{EUT}	W
Reactive power [b]	Q_{EUT}	VA
Voltage waveform [d, e, f, g]		
Current waveform [d, e, f, g]		
EUT (relay) output control signal [d]		
Run-on time	t_R	s
Stopping signal [h]	SS	--
Test load [b]		
Resistive load current	I_R	A
Inductive load current	I_L	A
Capacitive load current	I_C	A
AC (utility) power source [b]		
Utility active power [i]	P_{ac}	W
Utility reactive power [i]	Q_{ac}	VAr
Utility current [i]	I_{ac}	A

[a] If applicable.

[b] Record values measured before switch S1 is opened.

[c] Recorded when the test is carried out using a PV array, Pyranometer should be fast response silicon-type not thermopile-type.

[d] The response time of voltage and current transducer shall be suitable for the sampling rate used.

[e] The waveform, AC voltage and current, shall be measured on all phases.

[f] The waveform data shall be recorded from the beginning of the islanding test until the EUT ceases output. The measurement of time shall have an accuracy and resolution of better than 1 ms.

[g] When the waveform is recorded, the synchronizing signal of the S1 opening and stopping signal may be simultaneously recorded.

[h] If available from the EUT.

[i] Signal shall be filtered as necessary to provide fundamental (50 Hz or 60 Hz) frequency value. Fundamental values will ignore incidental harmonics, caused by utility voltage distortion, absorbed by the load and EUT filtering capacitors.

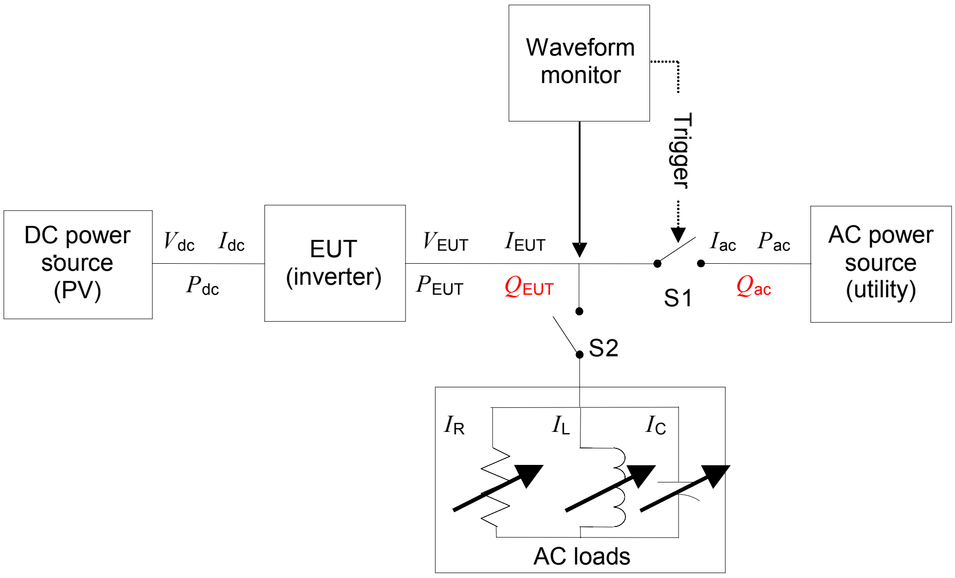

Figure 1 – Test circuit for islanding detection function in a power conditioner (inverter)

5 Testing equipment

5.1 Measuring instruments

Waveform observation shall be measured by a device with memory function, for example, a storage or digital oscilloscope or high speed data acquisition system. The waveform measurement/capture device shall be able to record the waveform from the beginning of the islanding test until the EUT ceases to energize the island. For multi-phase EUT, all phases shall be monitored. A waveform monitor designed to detect and calculate the run-on time may be used.

For multi-phase EUT, the test and measurement equipment shall record each phase current and each phase-to-neutral or phase-to phase voltage, as appropriate, to determine fundamental frequency, active and reactive power flow of the fundamental frequency over the duration of the test. Anti-aliasing filters and sampling frequencies appropriate to the measurement of the fundamental frequency component shall be applied. A sampling rate of 10 kHz or higher is recommended. The minimum measurement accuracy shall be 1 % or less of rated EUT nominal output voltage and 1 % or less of rated EUT output current. Current, active power, and reactive power measurements through switch S1 used to determine the circuit balance conditions shall report the fundamental (50 Hz or 60 Hz) component.

5.2 DC power source

As DC power source a PV array simulator (preferred) or a PV array or a current and voltage limited DC power supply with series resistance may be used. If the EUT can operate in utility-interconnected mode from a storage battery, a DC power source may be used in lieu of a battery as long as the DC power source shall not be the limiting device as far as the maximum EUT input current is concerned.

The DC power source shall provide voltage and current necessary to meet the testing requirements described in Clause 6.

5.2.1 PV array simulator

A unit intended to be energized directly from a photovoltaic source shall be energized from a supply that simulates the current-voltage characteristics and time response of a photovoltaic array. The tests shall be conducted at the input voltage defined in Table 2 below, and the current shall be limited to 1,5 times the rated photovoltaic input current, except when specified otherwise by the test requirements.

A PV array simulator is recommended, however, any type of power source may be used if it does not influence the test results.

Table 2 – Specification of array simulator (test conditions)

Items [a]	Conditions
Output power	Sufficient to provide maximum EUT output power and other levels specified by test conditions of Table 5.
Response speed [b]	The response time of a simulator to a step in output voltage due to a 5 % load change, should result in a settling of the output current to within 10 % of its final value in less than 1 ms.
Stability	Excluding the variations caused by the EUT MPPT, simulator output power should remain stable within 2 % of specified power level over the duration of the test: from the point where load balance is achieved until the island condition is cleared or the allowable run-on time is exceeded.
Fill factor [c]	0,25 to 0,8

[a] For the purpose of this standard, it is assumed that there is no influence of cell technology on islanding detection.

[b] Response speed is indicated to avoid influence caused by MPPT control system, ripple frequency on DC side of a EUT, or active methods of anti islanding.

[c] Fill factor = $(V_{mp} \times I_{mp})/(V_{oc} \times I_{sc})$, where V_{mp} and I_{mp} are the maximum power point voltage and current, respectively, V_{oc} is the open circuit voltage, and I_{sc} is the short circuit current. It should be maintained at one value for all test conditions

5.2.2 PV array

A PV array used as the EUT input source shall be capable of EUT maximum input power at minimum and maximum EUT input operating voltage. Testing is limited to times when the irradiance varies by no more than 2 % over the duration of the test as measured by a silicon-type pyranometer or reference device. It may be necessary to adjust the array configuration to achieve the input voltage and power levels prescribed in 6.1.

Table 3 – PV array test conditions

Items	Conditions
Output power	Sufficient to provide maximum EUT output power and other levels specified by test conditions of Table 5.
Climate condition	Irradiance, ambient temperature, etc.

To achieve a balanced load condition, the output of the PV array shall be stable. Thus, it is important to perform the test only during times of stable irradiance (e.g. clear sky, near solar noon).

5.2.3 Current and voltage limited DC power supply with series resistance

A DC power source used as the EUT input source shall be capable of EUT maximum AC output power at minimum and maximum EUT AC output operating voltage.

The power source should provide adjustable current and voltage limits, set to provide the desired short circuit current and open circuit voltage when combined with the series and shunt resistance described below.