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REDLINE VERSION

TECHNICAL SPECIFICATION

Utility-interconnected photovoltaic inverters – Test procedure for ~~low~~ under voltage ride-through measurements

colour inside

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UTILITY-INTERCONNECTED PHOTOVOLTAIC INVERTERS – TEST PROCEDURE FOR ~~LOW~~ UNDER VOLTAGE RIDE-THROUGH MEASUREMENTS

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- the subject is still under technical development or where, for any other reason, there is the future but no immediate possibility of an agreement on an International Standard.

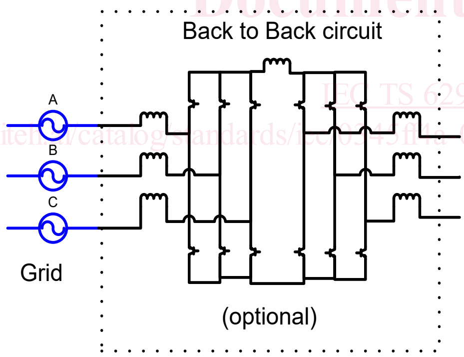
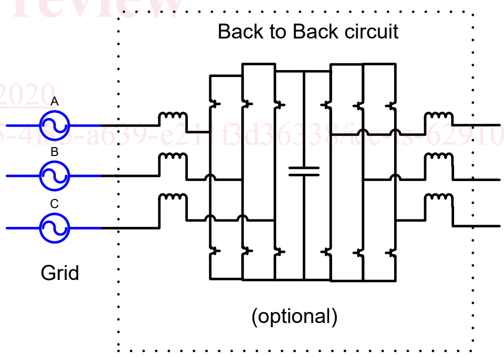
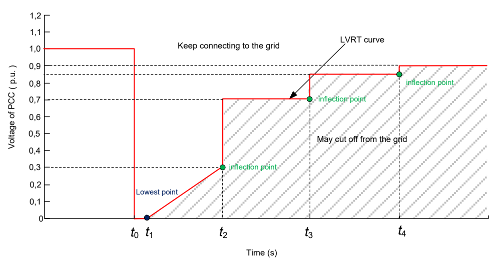
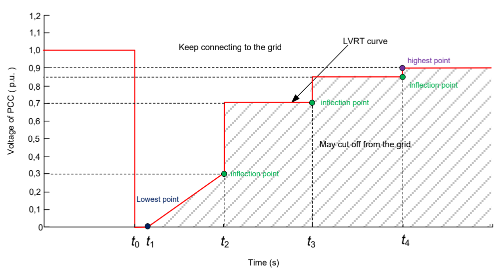
Technical Specifications are subject to review within three years of publication to decide whether they can be transformed into International Standards.

IEC TS 62910, which is a technical specification, has been prepared by IEC technical committee 82: Solar photovoltaic energy systems.

This second edition cancels and replaces the first edition issued in 2015, and constitutes a technical revision.

It remains a TS because it is limited to providing recommended practices for UVRT testing in the context of non-uniform grid-codes lacking international consensus, and the rapid development of test technology in recent years.

The main technical changes with regard to the previous edition are as follows:

Clause	Previous edition	Present edition
3.1.12	the voltage support of EUT in accordance with the voltage drops. The K-factor is to be specified by the EUT manufacturer	the K-factor is to be supplied by the EUT manufacturer meeting additional requirements imposed by national standards and/or local codes
Figure 2		
4.3.4	The test circuit essentially comprises a voltage source with a low internal resistance combined with broadband amplifiers......	The test circuit essentially comprises a voltage source with a low internal resistance combined optionally with broadband amplifiers......
Table 3	d The test should be carried out under specified K-factor provided by local manufacture.	d The test should be carried out under specified K-factor provided by manufacture meeting additional requirements imposed by national standards and/or local codes.
Figure 4		

5.2	NOTE The example shows two types of points on the UVRT curve: the lowest point and the inflection point. Tests must be carried out at both types of points	The example shows three types of points on the UVRT curve: the highest point, the lowest point and the inflection point. Tests shall be carried out at above types of points.
5.3.1	Prior to the fault simulation tests, the EUT should run in normal operating mode. The selected UVRT curve should be used to identify voltage drop points, including the lowest point and the inflection point, ……	Prior to the fault simulation tests, the EUT should run in normal operating mode. The selected UVRT curve should be used to identify voltage drop points, including the highest point, the lowest point and the inflection point, ……

The text of this Technical Specificationis based on the following documents:

Draft TS	Report on voting
82/1607/DTS	82/1640A/RVDTS

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

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

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

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

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UTILITY-INTERCONNECTED PHOTOVOLTAIC INVERTERS – TEST PROCEDURE FOR ~~LOW~~ UNDER VOLTAGE RIDE-THROUGH MEASUREMENTS

1 Scope

This document provides a test procedure for evaluating the performance of ~~Low~~ Under Voltage Ride-Through (~~LVRT~~ UVRT) functions in inverters used in utility-interconnected Photovoltaic (PV) systems.

This document is most applicable to large systems where PV inverters are connected to utility high voltage (HV) distribution systems. However, the applicable procedures may also be used for low voltage (LV) installations in locations where evolving ~~LVRT~~ UVRT requirements include such installations, e.g. single-phase or 3-phase systems.

The assessed ~~LVRT~~ UVRT performance is valid only for the specific configuration and operational mode of the inverter under test. Separate assessment is required for the inverter in other factory or user-settable configurations, as these may cause the inverter ~~LVRT~~ UVRT response to behave differently.

The measurement procedures are designed to be as non-site-specific as possible, so that ~~LVRT~~ UVRT characteristics measured at one test site, for example, can also be considered valid at other sites.

This document is for testing of PV inverters, though it contains information that may also be useful for testing of a complete PV power plant consisting of multiple inverters connected at a single point to the utility grid. It further provides a basis for utility-interconnected PV inverter numerical simulation and model validation.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

~~IEC 61400-21:2008, *Wind turbines – Part 21: Measurement and assessment of power quality characteristics of grid connected wind turbines*~~

IEC TS 61836, *Solar photovoltaic energy systems – Terms, definitions and symbols*

3 Terms, definitions, symbols and abbreviated terms

3.1 Terms, definitions and symbols

For the purposes of this document, the terms and definitions in IEC TS 61836 and ~~symbols~~ the following apply.

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

- IEC Electropedia: available at http://www.electropedia.org/

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

3.1.1
drop depth
magnitude of voltage drop during a fault or simulated fault, as a percentage of the nominal supply voltage

3.1.2
double drop
sudden decline of the nominal voltage to a value below 90 % of the voltage of point of common coupling (PCC), followed after a short time by a voltage recovery, which ~~happened~~ happens twice

Note 1 to entry: Voltage changes which do not reduce the voltage to below 90 % of the voltage of PCC are not considered to be voltage drops.

3.1.3
equipment under test
EUT
equipment on which these tests are performed and refers to the utility-interconnected PV inverter. During test period, EUT is connected with PV simulator instead of real PV modules on the direct current (DC) side, while alternating current (AC) side is connected with grid

~~**3.1.4**~~
~~**IT system**~~
~~IT power system has all live parts isolated from earth or one point connected to earth through an impedance. The exposed-conductive-parts of the electrical installation are earthed independently or collectively or to the earthing of the system~~

~~[SOURCE: IEC 60364-1:2005, 312.2.3]~~

3.1.4
I_q
output reactive current of EUT

3.1.5
~~low~~ under voltage ride through
~~LVRT~~ UVRT
capability of an inverter to continue generating power to connected loads during a limited duration loss or drop of grid voltage

~~**3.1.7**~~
~~**maximum MPP voltage**~~
~~maximum voltage at which the EUT can convert its rated power under MPPT conditions~~

~~[SOURCE: EN 50530:2010]~~

3.1.6
maximum power point tracking
MPPT
control strategy of operation at maximum power point or nearby

~~**3.1.9**~~
~~**minimum MPP voltage**~~
~~minimum voltage at which the EUT can convert its rated power under MPPT conditions~~

~~[SOURCE: EN 50530:2010]~~

3.1.7
***N*EUT**
access point of the EUT during the test

3.1.8
***P*N**
rated power of EUT

3.1.9
point of common coupling
PCC
point of a power supply network, electrically nearest to a particular load, at which other loads are, or may be, connected

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

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

[SOURCE: IEC 60050-161:1990, 161-07-15]

3.1.10
proportionality constant K
K-factor
~~voltage support of EUT in accordance with the voltage drops. the K-factor is to be specified by the EUT manufacturer.~~
the K-factor is to be supplied by the EUT manufacturer meeting additional requirements imposed by national standards and/or local codes

3.1.11
PV array simulator
simulator that has I-V characteristics equivalent to a PV array

~~**3.1.15**~~
~~**PV simulator MPP voltage**~~
~~$U_{MPP, PVS}$~~
~~MPP voltage of the setting PV curve that is provided by the PV simulator~~

3.1.12
***S*EUT**
apparent short-circuit power at N_{EUT}

$S_{EUT} = I_{sc} \times U_N$, I_{sc} refer to short-circuit current at N_{EUT} during the no-load test

3.1.13
single drop
sudden decline of the nominal voltage to a value below 90 % of the voltage of PCC, followed after a short time by a voltage recovery, which ~~happened~~ happens once

Note 1 to entry: Voltage changes which do not reduce the voltage to below 90 % of the voltage of PCC are not considered to be voltage drops.

3.1.14
***Z*grid**
grid short-circuit impedance value of the ~~MP1~~ main point (MP) 1 (see Figure 1)

3.1.15
***Z*i**
impedance value between the fault point and PCC

3.1.16
Z_p
impedance value between the fault point and EUT

3.2 Abbreviated terms

AC	alternating current
A/D	analog to digital
DC	direct current
EUT	equipment under test
HV	high voltage
LV	low voltage
MV	middle voltage
PV	photovoltaic
RMS	root mean square
UVRT	under voltage ride through

4 Test circuit and equipment

4.1 General

The circuits and equipment described in this clause are developed to allow tests that simulate the full range of anticipated grid faults, including:

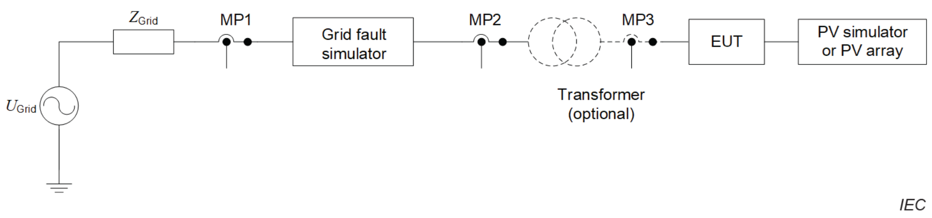
- Single phase to ground fault (any phase).
- Two phase isolated fault, between any two phases.
- Two phase grounded fault, involving any two phases.
- Three phase short-circuit fault.

A full discussion of these faults and the resulting impact on voltage magnitude and phase angles is included in Annex A.

The short circuit emulator and grid simulator described in 4.3.3 and 4.3.4 are informative examples and are not intended to restrict design flexibility. Other designs may be used to achieve equivalent test functionality.

4.2 Test circuit

The ~~LVRT~~ UVRT test circuit includes a DC source, the EUT, a grid fault simulator and the grid. A PV simulator (or PV array) provides input energy for the EUT. The output of the EUT is connected to the grid via a grid fault simulator, as shown in Figure 1.



NOTE MP1 is the measurement point between the grid and the grid fault simulator; MP2 is the measurement point at the high voltage side of the transformer; MP3 is the measurement point at the low voltage side of the transformer.

Figure 1 – Testing circuit diagram

4.3 Test equipment

4.3.1 Measuring instruments

Waveforms shall be measured by a device with memory function, for example, a storage or digital oscilloscope, or a high speed data acquisition device. Accuracy of the oscilloscope or data acquisition system should be at least 0,2 % of full scale. The analogue to A/D of the measurement device shall have at least 12 bit resolution (in order to maintain the required measurement accuracy).

~~Voltage transducers (or~~ Voltage transformers~~)~~ and current ~~transducers (or current~~ transformers~~)~~ are the required sensors for measurement. The accuracy of the transducers should be 0,5 % of full scale or better. It is necessary to select the transducer measuring range depending on the normal value of the signal to be measured. The selected measuring range shall not exceed 150 % of the normal value of the measured signal. The transducer accuracy requirements are shown in Table 1.

Table 1 – Accuracy of measurements

Measurement device	Accuracy	
Data acquisition device	0,2 %	full scale
Voltage ~~transducer~~ transformer	0,5 %	full scale
Current ~~transducer~~ transformer	0,5 %	full scale

4.3.2 DC source

A PV array, PV array simulator or controlled DC source with PV characteristics may be used as the DC power source to supply input energy for the ~~LVRT~~ UVRT test. As the EUT input source, the DC power source shall be capable of supplying the EUT maximum input power and other power levels during the test, at minimum and maximum input operating voltages of the EUT.

The PV simulator should emulate the current/voltage characteristic of the PV module or PV array for which the EUT is designed. The response time of a PV simulator should not be longer than the MPP tracking response time of EUT.

For a EUT under test without galvanic isolation between the DC side and AC side, the output of the PV simulator shall not be earthed.

The equivalent capacitance between the output of the PV simulator and earth should be as low as possible in order to minimize the impact on the EUT.

A PV array used as the EUT input source shall be capable of matching the EUT input power levels specified by the test conditions. It is necessary to select a period of time in which the solar irradiance is stable and does not vary more than 5 % during the test.

4.3.3 Short-circuit emulator

As part of the grid simulator device, the short-circuit emulator is used to create the voltage drops due to short-circuits between the two or three phases, or between one or two phases to ground, via the impedance network Z_1 and Z_2 as shown in the test device layout in Figure 2.

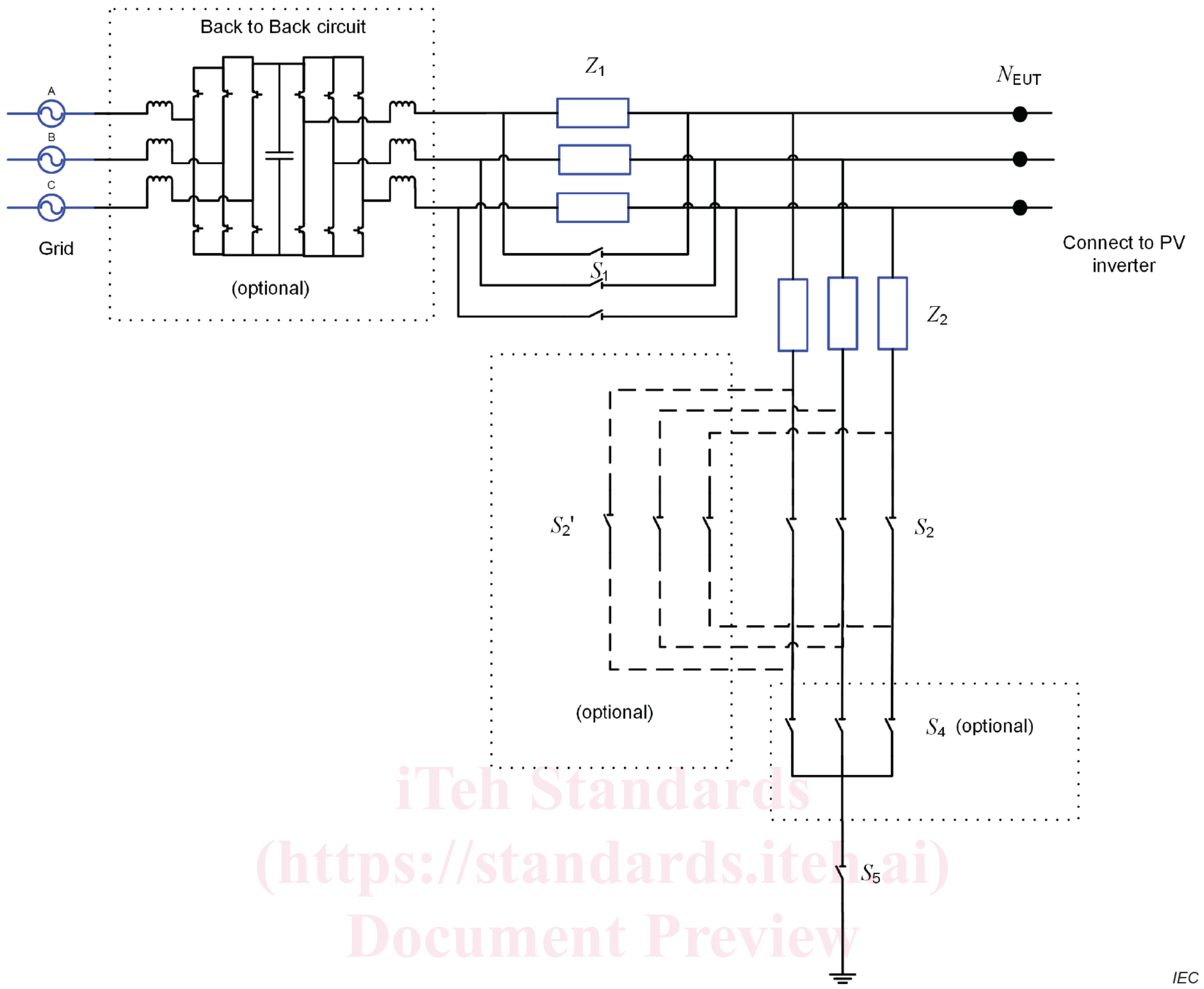


Figure 2 – Short-circuit emulator

The impedance Z_1 is used to limit the effect of the short circuit on the utility service that powers the test circuit. The sizing of Z_1 shall therefore account for all test sequences to be performed and limit the short-circuit current taken from the grid to values that do not cause an excessive reduction of the grid voltage. Considering an acceptable voltage reduction of at most 5 % when performing the test, the minimum value of Z_1 shall be at least 20 × Z_{Grid}, where Z_{Grid} is the grid short-circuit impedance measured at the test circuit connection point.

To ensure that the test is realistic, however, the apparent short-circuit power (S_{EUT}) available at the EUT connection node N_{EUT} should be at least equal to 3×Pn, where Pn is the rated power of the EUT (minimum value S_{EUT} > 3 × Pn, recommended ~~S_{EUT} = 5 to 6 × Pn~~ 5 × Pn < S_{EUT} < 6 × Pn). This means during the short-circuit tests, the contribution of current through Z_1 and Z_2 from the grid remains dominant compared to the current contributed by the EUT. In this way, the inverter current does not create a significant voltage rise for the duration of the test relative to the no-load drop.

The two conditions described above define the minimum and maximum limits of Z_1. The two conditions combined also define the limit criteria for the choice of a grid infrastructure suitable for performing the test with the impedance circuit. If the grid infrastructure cannot meet above requirements, an alternative test circuit utilizing a back-to-back converter is allowed, as shown in Figure 2 may be added to reduce the grid short-circuit impedance Z_{Grid}.