IEC 61215-2

Edition 1.0 2016-03

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

Terrestrial photovoltaic (PV) modules – Design qualification and type approval – Part 2: Test procedures

Modules photovoltaïques (PV) pour applications terrestres – Qualification de la conception et homologation – Partie 2: Procédures d'essai

IEC 61215-2:2016-03(en-fr)

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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CONTENTS

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TERRESTRIAL PHOTOVOLTAIC (PV) MODULES – DESIGN QUALIFICATION AND TYPE APPROVAL –

Part 2: Test procedures

FOREWORD

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International Standard IEC 61215-2 has been prepared by IEC technical committee 82: Solar photovoltaic energy systems.

This first edition of IEC 61215-2 cancels and replaces the second edition of IEC 61215 (2005) and parts of the second edition of 61646 (2008) and constitutes a technical revision.

The main technical changes with regard to these previous editions are as follows:

This standard includes the testing procedures – formally Clause 10 – of the previous edition. Revisions were made to subclauses NMOT (replaces NOCT – MQT 05), performance measurements (MQT 06), robustness of terminations (MQT 14) and stabilization (MQT 19).

The text of this standard is based on the following documents:

FDIS	Report on voting
82/1048/FDIS	82/1076/RVD

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

A list of all parts in the IEC 61215 series, published under the general title *Terrestrial photovoltaic (PV) modules – Design qualification and type approval*, can be found on the IEC website.

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

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

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- withdrawn,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

The contents of the corrigendum of March 2018 have been included in this copy.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

Whereas Part 1 of this standard series describes requirements (both in general and specific with respect to device technology), the sub-parts of Part 1 define technology variations and Part 2 defines a set of test procedures necessary for design qualification and type approval. The test procedures described in Part 2 are valid for all device technologies.

TERRESTRIAL PHOTOVOLTAIC (PV) MODULES – DESIGN QUALIFICATION AND TYPE APPROVAL –

Part 2: Test procedures

1 Scope and object

This International Standard series lays down IEC requirements for the design qualification and type approval of terrestrial photovoltaic modules suitable for long-term operation in general open-air climates, as defined in IEC 60721-2-1. This part of IEC 61215 is intended to apply to all terrestrial flat plate module materials such as crystalline silicon module types as well as thin-film modules.

This standard does not apply to modules used with concentrated sunlight although it may be utilized for low concentrator modules (1 to 3 suns). For low concentration modules, all tests are performed using the current, voltage and power levels expected at the design concentration.

The objective of this test sequence is to determine the electrical and thermal characteristics of the module and to show, as far as possible within reasonable constraints of cost and time, that the module is capable of withstanding prolonged exposure in general open-air climates. The actual lifetime expectancy of modules so qualified will depend on their design, their environment and the conditions under which they are operated.

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.

IEC 60050, *International Electrotechnical Vocabulary* (available at http://www.electropedia.org)

IEC 60068-1, *Environmental testing – Part 1: General and guidance*

IEC 60068-2-21, *Environmental testing – Part 2-21: Tests – Test U: Robustness of terminations and integral mounting devices*

IEC 60068-2-78, *Environmental testing – Part 2-78: Tests – Test Cab: Damp heat, steady state*

IEC 60721-2-1, *Classification of environmental conditions – Part 2-1: Environmental conditions appearing in nature – Temperature and humidity*

IEC 60891, *Photovoltaic devices – Procedures for temperature and irradiance corrections to measured I-V characteristics*

IEC 60904-1, *Photovoltaic devices – Part 1: Measurements of photovoltaic current-voltage characteristics*

IEC 60904-2, *Photovoltaic devices – Part 2: Requirements for photovoltaic reference devices*

IEC 60904-3, *Photovoltaic devices – Part 3: Measurement principles for terrestrial photovoltaic (PV) solar devices with reference spectral irradiance data*

IEC 60904-7, *Photovoltaic devices – Part 7: Computation of the spectral mismatch correction for measurements of photovoltaic devices*

IEC 60904-8, *Photovoltaic devices – Part 8: Measurement of spectral responsivity of a photovoltaic (PV) device*

IEC 60904-9, *Photovoltaic devices – Part 9: Solar simulator performance requirements*

IEC 60904-10, *Photovoltaic devices – Part 10: Methods of linearity measurement*

IEC 61215-1, *Terrestrial photovoltaic (PV) modules – Design qualification and type approval – Part 1: Test requirements*

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

IEC 61853-2, *Photovoltaic (PV) module performance testing and energy rating – Part 2: Spectral response, incidence angle, and module operating temperature measurements*[1]

IEC 62790, *Junction boxes for photovoltaic modules – Safety requirements and tests*

ISO 868, *Plastics and ebonite – Determination of indentation hardness by means of a durometer (Shore hardness)*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050 and IEC TS 61836 apply, as well as the following.

3.1
accuracy <of a measuring instrument>

quality which characterizes the ability of a measuring instrument to provide an indicated value close to a true value of the measurand [≈ VIM 5.18]

Note 1 to entry: This term is used in the "true value" approach.

Note 2 to entry: Accuracy is all the better when the indicated value is closer to the corresponding true value.

[SOURCE: IEC 60050-311:2001, 311-06-08]

3.2
control device
irradiance sensor (such as a reference cell or module) that is used to detect drifts and other problems of the solar sun simulator

3.3
electrically stable power output level
state of the PV module where it will operate under long-term natural sunlight exposure in general open-air climates, as defined in IEC 60721-2-1

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1 To be published.

3.4
repeatability <of results of measurements>
closeness of agreement between the results of successive measurements of the same measurand, carried out under the same conditions of measurement, i.e.:

– by the same measurement procedure,
– by the same observer,
– with the same measuring instruments,
– used under the same conditions,
– in the same laboratory,

at relatively short intervals of time [≈ VIM 3.6].

Note 1 to entry: The concept of "measurement procedure" is defined in VIM 2.5.

[SOURCE: IEC 60050-311:2001, 311-06-06]

3.5
reproducibility <of measurements>
closeness of agreement between the results of measurements of the same value of a quantity, when the individual measurements are made under different conditions of measurement:

– principle of measurement,
– method of measurement,
– observer,
– measuring instruments,
– reference standards,
– laboratory,
– under conditions of use of the instruments, different from those customarily used,

after intervals of time relatively long compared with the duration of a single measurement [≈ VIM 3.7].

Note 1 to entry: The concepts of "principle of measurement" and "method of measurement" are respectively defined in VIM 2.3 and 2.4.

Note 2 to entry: The term "reproducibility" also applies to the instance where only certain of the above conditions are taken into account, provided that these are stated.

[SOURCE: IEC 60050-311:2001, 311-06-07]

4 Test procedures

4.1 Visual inspection (MQT 01)

4.1.1 Purpose

To detect any visual defects in the module.

4.1.2 Procedure

Carefully inspect each module under an illumination of not less than 1 000 lux for conditions and observations as defined in IEC 61215-1.

Make note of and/or photograph the nature and position of any cracks, bubbles or delaminations, etc., which may worsen and adversely affect the module performance in subsequent tests.

4.1.3 Requirements

No evidence of major visual defects permitted, as defined in IEC 61215-1.

4.2 Maximum power determination (MQT 02)

4.2.1 Purpose

To determine the maximum power of the module after stabilization as well as before and after the various environmental stress tests. For determining the power loss from the stress tests, reproducibility of the test is a very important factor.

4.2.2 Apparatus

a) A radiant source (natural sunlight or a solar simulator class BBA or better in accordance with IEC 60904-9).

b) A PV reference device in accordance with IEC 60904-2. If a class BBA simulator or better is used, the reference device shall be a reference module of the same size with the same cell technology to match spectral responsivity. If such a matched reference device is not available one of the following two options need to be followed:

   1) a Class AAA simulator shall be utilized, or

   2) the spectral responsivity of the module according to IEC 60904-8 and the spectral distribution of the solar simulator need to be measured and the module data corrected according to IEC 60904-7.

c) A suitable mount for supporting the test specimen and the reference device in a plane normal to the radiant beam.

d) Apparatus for measuring an I-V curve in accordance with IEC 60904-1.

4.2.3 Procedure

Determine the current-voltage characteristic of the module in accordance with IEC 60904-1 at a specific set of irradiance and temperature conditions (a recommended range is a cell temperature between 25 °C and 50 °C and an irradiance between 700 W/m^2 and 1 100 W/m^2) using natural sunlight or a class BBA or better simulator conforming to the requirements of IEC 60904-9. In special circumstances when modules are designed for operation under a different range of conditions, the current-voltage characteristics can be measured using temperature and irradiance levels similar to the expected operating conditions. For linear modules (as defined in IEC 60904-10) temperature and irradiance corrections can be made in accordance with IEC 60891 in order to compare sets of measurements made on the same module before and after environmental tests. For nonlinear modules (as defined in IEC 60904-10) the measurement shall be performed within ± 5 % of the specified irradiance and within ± 2 °C of the specified temperature. However, every effort should be made to ensure that peak power measurements are made under similar operating conditions, that is minimize the magnitude of the correction by making all peak power measurements on a particular module at approximately the same temperature and irradiance.

4.3 Insulation test (MQT 03)

4.3.1 Purpose

To determine whether or not the module is sufficiently well insulated between live parts and accessible parts.

4.3.2 Apparatus

a) d.c. voltage source, with current limitation, capable of applying 500 V or 1 000 V plus twice the maximum system voltage of the module (IEC 61215-1).

b) An instrument to measure the insulation resistance.

4.3.3 Test conditions

The test shall be made on modules at ambient temperature of the surrounding atmosphere (see IEC 60068-1) and in a relative humidity not exceeding 75 %.

4.3.4 Procedure

a) Connect the shorted output terminals of the module to the positive terminal of a d.c. insulation tester with a current limitation.

b) Connect the exposed metal parts of the modules to the negative terminal of the tester. If the modules has no frame or if the frame is a poor electrical conductor, wrap a conductive foil around the edges. Cover all polymeric surfaces (front- / backsheet, junction box) of the module with conductive foil. Connect all foil covered parts also to the negative terminal of the tester.

   Some module technologies may be sensitive to static polarization if the module is maintained at positive voltage to the frame. In this case, the connection of the tester shall be done in the opposite way. If applicable, information with respect to sensitivity to static polarization shall be provided by manufacturer.

c) Increase the voltage applied by the tester at a rate not exceeding 500 V/s to a maximum equal to 1 000 V plus twice the maximum system voltage (IEC 61215-1). If the maximum system voltage does not exceed 50 V, the applied voltage shall be 500 V. Maintain the voltage at this level for 1 min.

d) Reduce the applied voltage to zero and short-circuit the terminals of the test equipment to discharge the voltage build-up in the module.

e) Remove the short circuit.

f) Increase the voltage applied by the test equipment at a rate not exceeding 500 V/s to 500 V or the maximum system voltage for the module, whichever is greater. Maintain the voltage at this level for 2 min. Then determine the insulation resistance.

g) Reduce the applied voltage to zero and short-circuit the terminals of the test equipment to discharge the voltage build-up in the module.

h) Remove the short circuit and disconnect the test equipment from the module.

4.3.5 Test requirements

a) No dielectric breakdown or surface tracking during 4.3.4 c).

b) For modules with an area of less than 0,1 m^2 the insulation resistance shall not be less than 400 MΩ.

c) For modules with an area larger than 0,1 m^2 the measured insulation resistance times the area of the module shall not be less than 40 MΩ·m^2.

4.4 Measurement of temperature coefficients (MQT 04)

Determine the temperature coefficients of current (α), voltage (β) and peak power (δ) from module measurements as specified in IEC 60891. The coefficients so determined are valid at the irradiance at which the measurements were made. See IEC 60904-10 for evaluation of module temperature coefficients at different irradiance levels.

NOTE For linear modules in accordance to IEC 60904-10, temperature coefficients are valid over an irradiance range of ± 30 % of this level.

4.5 Measurement of nominal module operating temperature (NMOT) (MQT 05)

4.5.1 General

The power of PV-modules depends on the cell temperature. The cell temperature is primarily affected by the ambient temperature, the solar irradiance, and the wind speed.

NMOT is defined as the equilibrium mean solar cell junction temperature within an open-rack mounted module operating near peak power in the following standard reference environment (SRE):

- Tilt angle: (37 ± 5)°
- Total irradiance: 800 W/m^2
- Ambient temperature: 20 °C
- Wind speed: 1 m/s
- Electrical load: A resistive load sized such that the module will operate near its maximum power point at STC or an electronic maximum power point tracker (MPPT).

NOTE NMOT is similar to the former NOCT except that it is measured with the module under maximum power rather than in open circuit. Under maximum power conditions (electric) energy is withdrawn from the module, therefore less thermal energy is dissipated throughout the module than under open-circuit conditions. Therefore NMOT is typically a few degrees lower than the former NOCT.

NMOT can be used by the system designer as a guide to the temperature at which a module will operate in the field, and it is therefore a useful parameter when comparing the performance of different module designs. However, the actual operating temperature at any particular time is affected by the mounting structure, distance from ground, irradiance, wind speed, ambient temperature, sky temperature and reflections and emissions from the ground and nearby objects. For accurate performance predictions, these factors shall be taken into account.

In the case of modules not designed for open-rack mounting, the method may be used to determine the equilibrium mean solar cell junction temperature in the SRE, with the module mounted as recommended by the manufacturer.

4.5.2 Principle

This method is based on gathering actual measured module temperature data under a range of environmental conditions including the SRE. The data are presented in a way that allows accurate and repeatable interpolation of the NMOT.

The temperature of the solar cell junction (T_J) is primarily a function of the ambient temperature (T_{amb}), the average wind speed (v) and the total solar irradiance (G) incident on the active surface of the module. The temperature difference (T_J – T_{amb}) is largely independent of the ambient temperature and is essentially linearly proportional to the irradiance at levels above 400 W/m^2.

The module temperature is modelled by: $T_J - T_{amb} = G / (u_0 - u_1 v)$

The coefficient u_0 describes the influence of the irradiance and u_1 the wind impact.

The NMOT value for T_J is then determined from the model formula above by using T_{amb} = 20 °C, irradiance G of 800 W/m^2 and a wind speed v of 1 m/s.

4.5.3 Test procedure

The data for calculating NMOT shall be acquired using the test method (Methodology for determining module operating temperature) in IEC 61853-2.