



# UL 61215-1-4

## STANDARD FOR SAFETY

Terrestrial Photovoltaic (PV) Modules –  
Design Qualification and Type Approval  
– Part 1-4: Special Requirements for  
Testing of Thin-Film  $\text{Cu(In,Ga)(S,Se)}_2$   
Based Photovoltaic (PV) Modules

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UL Standard for Safety for Terrestrial Photovoltaic (PV) Modules – Design Qualification and Type Approval – Part 1-4: Special Requirements for Testing of Thin-Film Cu(In,Ga)(S,Se)<sub>2</sub> Based Photovoltaic (PV) Modules, UL 61215-1-4

Second Edition, Dated July 28, 2021

### **Summary of Topics**

***UL 61215-1-4 is an adoption of IEC 61215-1-4, Terrestrial Photovoltaic (PV) Modules – Design Qualification and Type Approval – Part 1-4: Special requirements for testing of thin-film Cu(In,Ga)(S,Se)<sub>2</sub> based photovoltaic (PV) modules, (Second Edition, issued February 2021). Please note that there are no National Differences.***

The requirements are substantially in accordance with Proposal(s) on this subject dated May 21, 2021.

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ANSI/UL 61215-1-4-2021

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UL 61215-1-4

**Terrestrial Photovoltaic (PV) Modules – Design Qualification and Type**

**Approval – Part 1-4: Special Requirements for Testing of Thin-Film**

**Cu(In,Ga)(S,Se)<sub>2</sub> Based Photovoltaic (PV) Modules**

First Edition – April, 2018

**Second Edition**

**July 28, 2021**

This ANSI/UL Standard for Safety consists of the Second Edition.

The most recent designation of ANSI/UL 61215-1-4 as an American National Standard (ANSI) occurred on July 7, 2021. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, Title Page, or Preface. The IEC Foreword is also excluded from the ANSI approval of IEC-based standards.

Comments or proposals for revisions on any part of the Standard may be submitted to UL at any time. Proposals should be submitted via a Proposal Request in UL's On-Line Collaborative Standards Development System (CSDS) at <https://csds.ul.com>.

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## PREFACE

This UL Standard is based on IEC Publication IEC 61215-1-4: Second edition Terrestrial Photovoltaic (PV) Modules – Design Qualification and Type Approval – Part 1-4: Special requirements for testing of thin-film  $\text{Cu(In,Ga)(S,Se)}_2$  based photovoltaic (PV) modules. IEC publication IEC 61215-1-4 is copyrighted by the IEC.

This edition has been issued to satisfy UL Standards policy.

This UL Standard 61215-1-4 Standard for Terrestrial Photovoltaic (PV) Modules – Design Qualification and Type Approval – Part 1-4: Special Requirements for Testing of Thin-Film  $\text{Cu(In,Ga)(S,Se)}_2$  Based Photovoltaic (PV) Modules, is to be used in conjunction with the second edition of UL 61215-1 and the second edition of UL 61215-2.

Requirements of this Standard, where stated, amend the requirements of UL 61215-1 and UL 61215-2.

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Note – Although the intended primary application of this Standard is stated in its Scope, it is important to note that it remains the responsibility of the users of the Standard to judge its suitability for their particular purpose.

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## FOREWORD

### INTERNATIONAL ELECTROTECHNICAL COMMISSION

#### **TERRESTRIAL PHOTOVOLTAIC (PV) MODULES – DESIGN QUALIFICATION AND TYPE APPROVAL – Part 1-4: Special requirements for testing of thin-film Cu(In,Ga)(S,Se)<sub>2</sub> based photovoltaic (PV) modules**

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International Standard IEC 61215-1-4 has been prepared by IEC technical committee 82: Solar photovoltaic energy systems.

This second edition cancels and replaces the first edition of IEC 61215-1-4, issued in 2016, and constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- a) A cyclic (dynamic) mechanical load test (MQT 20) added.
- b) A test for detection of potential-induced degradation (MQT 21) added.
- c) A bending test (MQT 22) for flexible modules added.

Informative Annex A of 61215-1:2021 explains the background and reasoning behind some of the more substantial changes that were made in the IEC 61215 series in progressing from edition 1 to edition 2

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

FDIS	Report on voting
82/1827/FDIS	82/1852/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.

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

This standard is to be read in conjunction with IEC 61215-1:2021 and IEC 61215-2:2021.

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.

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.

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# TERRESTRIAL PHOTOVOLTAIC (PV) MODULES – DESIGN QUALIFICATION AND TYPE APPROVAL – Part 1-4: Special requirements for testing of thin-film Cu(In,Ga)(S,Se)<sub>2</sub> based photovoltaic (PV) modules

## 1 Scope

This document lays down requirements for the design qualification of terrestrial photovoltaic modules suitable for long-term operation in open-air climates. The useful service life of modules so qualified will depend on their design, their environment and the conditions under which they are operated. Test results are not construed as a quantitative prediction of module lifetime.

In climates where 98<sup>th</sup> percentile operating temperatures exceed 70 °C, users are recommended to consider testing to higher temperature test conditions as described in IEC TS 63126. Users desiring qualification of PV products with lesser lifetime expectations are recommended to consider testing designed for PV in consumer electronics, as described in IEC 63163 (under development). Users wishing to gain confidence that the characteristics tested in IEC 61215 appear consistently in a manufactured product may wish to utilize IEC 62941 regarding quality systems in PV manufacturing.

This document is intended to apply to all thin-film Cu(In,Ga)(S,Se)<sub>2</sub> based terrestrial flat plate modules. As such it addresses special requirements for testing of this technology supplementing IEC 61215-1:2021 and IEC 61215-2:2021 requirements for testing.

This document 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 irradiance, current, voltage and power levels expected at the design concentration.

The object of this test sequence is to determine the electrical 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 outdoors. Accelerated test conditions are empirically based on those necessary to reproduce selected observed field failures and are applied equally across module types. Acceleration factors may vary with product design and thus not all degradation mechanisms may manifest. Further general information on accelerated test methods including definitions of terms may be found in IEC 62506.

Some long-term degradation mechanisms can only reasonably be detected via component testing, due to long times required to produce the failure and necessity of stress conditions that are expensive to produce over large areas. Component tests that have reached a sufficient level of maturity to set pass/fail criteria with high confidence are incorporated into the IEC 61215 series via addition to Table 1 in IEC 61215-1. In contrast, the tests procedures described in this series, in IEC 61215-2, are performed on modules.

This document defines PV technology dependent modifications to the testing procedures and requirements per IEC 61215-1:2021 and IEC 61215-2:2021.

## 2 Normative references

The normative references of IEC 61215-1:2021 and IEC 61215-2:2021 are applicable without modifications.

### 3 Terms and definitions

This clause of IEC 61215-1:2021 is applicable without modifications.

### 4 Test samples

This clause of IEC 61215-1:2021 is applicable without modifications.

### 5 Marking and documentation

This clause of IEC 61215-1:2021 is applicable without modifications.

### 6 Testing

This clause of IEC 61215-1:2021 is applicable with the following modifications:

Special care has to be taken for stabilizing the power output of the module using MQT 19 procedure with specific requirements stated in [11.19](#) below.

### 7 Pass criteria

This clause of IEC 61215-1:2021 is applicable with the following modifications.

The maximum allowable value of reproducibility is set to  $r = 2,0$  %.

The maximum allowable value of measurement uncertainty is set to  $m_1 = 4,0$  % for modules containing single-junction cells, and  $m_1 = 5,0$  % for modules containing multi-junction cells.

### 8 Major visual defects

This clause of IEC 61215-1:2021 is applicable without modifications.

### 9 Report

This clause of IEC 61215-1:2021 is applicable without modifications.

### 10 Modifications

This clause of IEC 61215-1:2021 is applicable without modifications.

### 11 Test flow and procedures

The test flow from IEC 61215-1:2021 is applicable.

#### 11.1 Visual inspection (MQT 01)

This test of IEC 61215-2:2021 is applicable without modifications.

#### 11.2 Maximum power determination (MQT 02)

This test of IEC 61215-2:2021 is applicable without modifications.

### 11.3 Insulation test (MQT 03)

This test of IEC 61215-2:2021 is applicable without modifications.

### 11.4 Measurement of temperature coefficients (MQT 04)

This test of IEC 61215-2:2021 is applicable without modifications.

### 11.5 Placeholder section, formerly NMOT

This subclause of IEC 61215-2:2021 does not require technology-specific modifications.

### 11.6 Performance at STC (MQT 06.1)

This test of IEC 61215-2:2021 is applicable without modifications.

### 11.7 Performance at low irradiance (MQT 07)

This test of IEC 61215-2:2021 is applicable without modifications.

### 11.8 Outdoor exposure test (MQT 08)

This test of IEC 61215-2:2021 is applicable without modifications.

### 11.9 Hot-spot endurance test (MQT 09)

This test of IEC 61215-2:2021 is applicable with the following modifications:

Cu(In,Ga)(S,Se)<sub>2</sub> thin-film modules may exhibit performance changes with extended time in storage without light exposure (the “dark soak” effect). In order to minimize the influence of this dark soak effect, limit the time delay between the outdoor exposure or stabilization and the hot spot procedure to within 2 to 3 days. During the first hour after the hot-spot procedure is complete, no additional heating or light beyond room ambient shall be applied. If the time delay is to exceed 1 h, the modules are to be stored in the dark at ≤ 25 °C.

#### 11.9.1 Purpose

This subclause of IEC 61215-2:2021, test MQT 09, is applicable without modifications.

#### 11.9.2 Hot-spot effect

This subclause of IEC 61215-2:2021, test MQT 09, is applicable without modifications.

#### 11.9.3 Classification of cell interconnection

This subclause of IEC 61215-2:2021, test MQT 09, is applicable without modifications.

#### 11.9.4 Apparatus

This subclause of IEC 61215-2:2021, test MQT 09, is applicable without modifications.

### 11.9.5 Procedure

MQT 09.2 of IEC 61215-2:2021 shall be performed for any monolithically integrated (MLI) module design.

If the module is constructed by interconnection of cell-like substructures, MQT 09.1 of IEC 61215-2:2021 may be applicable.

### 11.9.6 Final measurements

This subclause of IEC 61215-2:2021, test MQT 09, is applicable without modifications.

### 11.9.7 Requirements

This subclause of IEC 61215-2:2021, test MQT 09, is applicable without modifications.

### 11.10 UV preconditioning test (MQT 10)

This test of IEC 61215-2:2021 is applicable without modifications.

### 11.11 Thermal cycling test (MQT 11)

This test of IEC 61215-2:2021 is applicable with the following modifications:

MQT 11 of IEC 61215-2:2021 can be conducted according to the following methods:

Method A) Perform MQT 11 as defined in IEC 61215-2:2021, with the technology specific current equal to  $0,1 \times \text{STC peak power current}$ . If  $0,1 \times \text{STC peak power current}$  is less than 100 mA, then 100 mA may be applied instead.

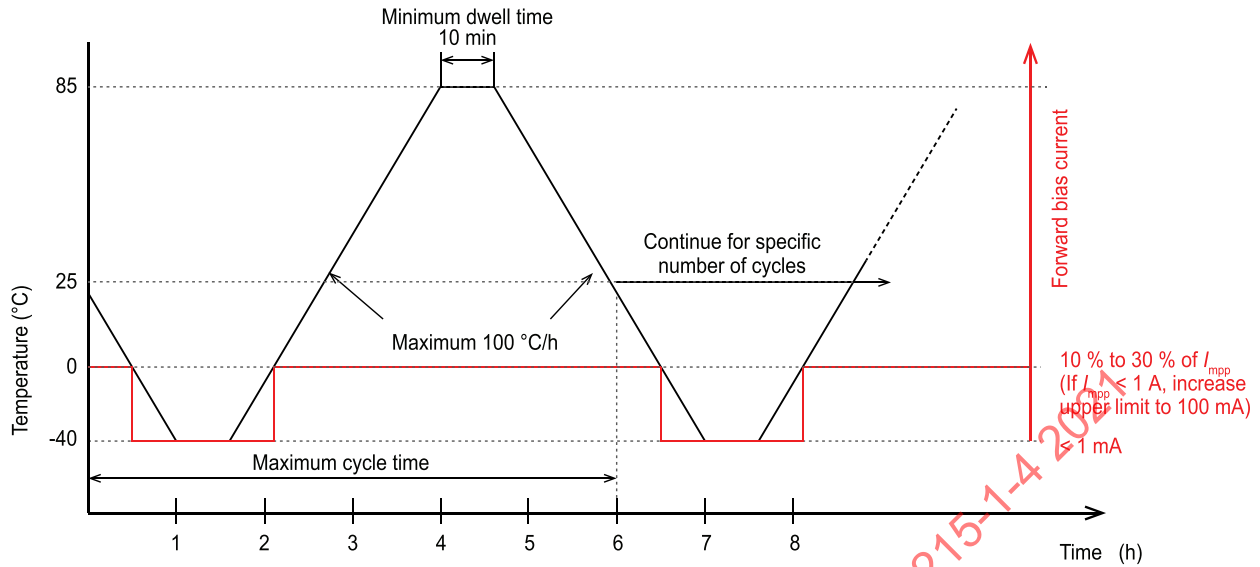
Method B) Perform MQT 11 as defined in IEC 61215-2:2021 with the following modifications:

During the thermal cycling test, set the continuous current flow during the heat up cycle to the technology specified current noted below at temperature from 0 °C to 85 °C. Maintain current flow during high temperature dwell and cool down cycle until the module temperature is below 0 °C. As necessary, adjust the chamber temperature to maintain module temperature below 85 °C.

The technology specific current which needs to be applied according to MQT11 of IEC 61215 2 shall be a forward bias current of  $0,1 \times \text{STC peak power current}$  to  $0,3 \times \text{STC peak power current}$ . If  $0,1 \times \text{STC peak power current}$  is less than 100 mA, then 100 mA may be applied instead.

The current flow applied during Method B is shown superimposed on the temperature cycle in [Figure 1](#).





su2511b

IEC

Figure 1

### Current flow using MQT 11 Method B

#### 11.12 Humidity-freeze test (MQT 12)

This test of IEC 61215-2:2021 is applicable with the following modifications:

MQT 12 of IEC 61215-2:2021 can be conducted according to the following methods:

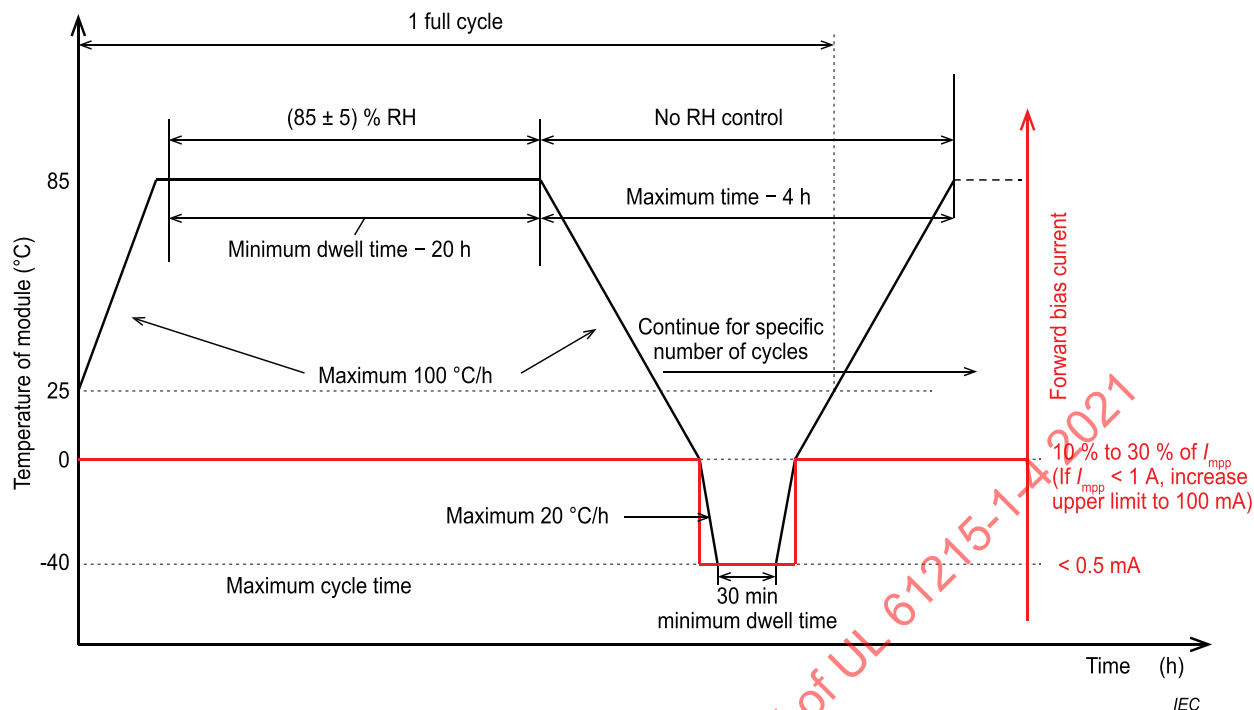
Method A) Perform MQT 12 as defined in IEC 61215-2:2021.

Method B) Perform MQT 12 as defined in IEC 61215-2:2021 with the following modifications:

During the humidity freeze test, set the continuous current flow during the heat up cycle to the technology specified current noted below at temperature from 0 °C to 85 °C. Maintain current flow during high temperature dwell and cool down cycle until module temperature has reached 0 °C. As necessary, adjust the chamber temperature to maintain module temperature below 85 °C.

The technology specific current which needs to be applied according to MQT12 of IEC 61215 2 in Method B shall be a forward bias current of  $0,1 \times \text{STC peak power current}$  to  $0,3 \times \text{STC peak power current}$ , with a minimum of 100 mA.

The current flow applied during Method B is shown superimposed on the humidity-freeze cycle in [Figure 2](#).



su2512b

**Figure 2**  
**Current flow using MQT 12 Method B**

### 11.13 Damp heat test (MQT 13)

This test of IEC 61215-2:2021 is applicable with the following modifications:

MQT 13 of IEC 61215-2:2021 can be conducted according to the following methods:

Method A) Perform MQT 13 as defined in IEC 61215-2:2021.

Method B) Perform MQT 13 as defined in IEC 61215-2:2021 with applied forward bias:

#### 11.13.1 Procedure

a) Attach a suitable temperature sensor (see apparatus requirements of MQT 11) to the front or back surface of the module(s) near the middle. If more than one module of the same type are tested simultaneously, it will suffice to monitor the temperature of one representative sample.

b) Connect the temperature-monitoring equipment to the temperature sensor(s). Connect each module individually to the appropriate voltage supply by connecting the positive terminal of the module to the positive terminal of the power supply and the second terminal accordingly. During the damp-heat set the applied voltage to  $V_{mpp} \pm 5\%$  at STC taken from the data-sheet and limit the current of the power supply to less than 25 % of  $I_{sc}$  at STC.

c) Throughout the test monitor the module's applied voltage and current. Report  $I$ - $V$  trend. If current limit is reached, applied voltage can drop below  $V_{mpp} \pm 5\%$  at STC.