

# INTERNATIONAL STANDARD



**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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**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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**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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**This redline version of the official IEC Standard allows the user to identify the changes made to the previous edition IEC 61215-1-4:2016. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.**

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 International 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 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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## 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 and object~~

~~This part of IEC 61215 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 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 61215-1:2016/2021 and IEC 61215-2:2016/2021 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 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 climates described in the scope. The actual lifetime expectancy of modules so qualified will depend on their design, their environment and the conditions under which they are operated.~~

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 61215-1:20162021 and IEC 61215-2:20162021.

## 2 Normative references

The normative references of IEC 61215-1:20162021 and IEC 61215-2:20162021 are applicable without modifications.

## 3 Terms and definitions

This clause of IEC 61215-1:20162021 is applicable without modifications.

## 4 Test samples

This clause of IEC 61215-1:20162021 is applicable without modifications.

## 5 Marking and documentation

This clause of IEC 61215-1:20162021 is applicable without modifications.

## 6 Testing

This clause of IEC 61215-1:20162021 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 61215-1:20162021 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 61215-1:20162021 is applicable without modifications.

## 9 Report

This clause of IEC 61215-1:20162021 is applicable without modifications.

## 10 Modifications

This clause of IEC 61215-1:20162021 is applicable without modifications.

## 11 Test flow and procedures

The test flow from IEC 61215-1:2016:2021 is applicable.

### 11.1 Visual inspection (MQT 01)

This test of IEC 61215-2:2016:2021 is applicable without modifications.

### 11.2 Maximum power determination (MQT 02)

This test of IEC 61215-2:2016:2021 is applicable without modifications.

### 11.3 Insulation test (MQT 03)

This test of IEC 61215-2:2016:2021 is applicable without modifications.

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

This test of IEC 61215-2:2016:2021 is applicable without modifications.

### ~~11.5 Measurement of nominal module operating temperature (NMOT) (MQT 05)~~ Placeholder section, formerly NMOT

~~This test of IEC 61215-2:2016 is applicable without modifications.~~

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

### ~~11.6 Performance at STC (MQT 06.1) and NMOT (MQT 06.2)~~

This test of IEC 61215-2:2016:2021 is applicable without modifications.

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

This test of IEC 61215-2:2016:2021 is applicable without modifications.

### 11.8 Outdoor exposure test (MQT 08)

This test of IEC 61215-2:2016:2021 is applicable without modifications.

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

This test of IEC 61215-2:2016:2021 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 61215-2:2016:2021, test MQT 09, is applicable without modifications.

#### 11.9.2 Hot-spot effect

This subclause of IEC 61215-2:2016:2021, test MQT 09, is applicable without modifications.

### 11.9.3 Classification of cell interconnection

This subclause of IEC 61215-2:2016:2021, test MQT 09, is applicable without modifications.

### 11.9.4 Apparatus

This subclause of IEC 61215-2:2016:2021, test MQT 09, is applicable without modifications.

### 11.9.5 Procedure

MQT 09.2 of IEC 61215-2:2016:2021 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 61215-2:2016:2021 may be applicable.

### 11.9.6 Final measurements

This subclause of IEC 61215-2:2016:2021, test MQT 09, is applicable without modifications.

### 11.9.7 Requirements

This subclause of IEC 61215-2:2016:2021, test MQT 09, is applicable without modifications.

### 11.10 UV preconditioning test (MQT 10)

This test of IEC 61215-2:2016:2021 is applicable without modifications.

### 11.11 Thermal cycling test (MQT 11)

This test of IEC 61215-2:2016:2021 is applicable with the following modifications:

~~The technology specific current which needs to be applied according to MQT 11 of IEC 61215-2:2016 shall be equal to  $0,1 \times$  STC peak power current.~~

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

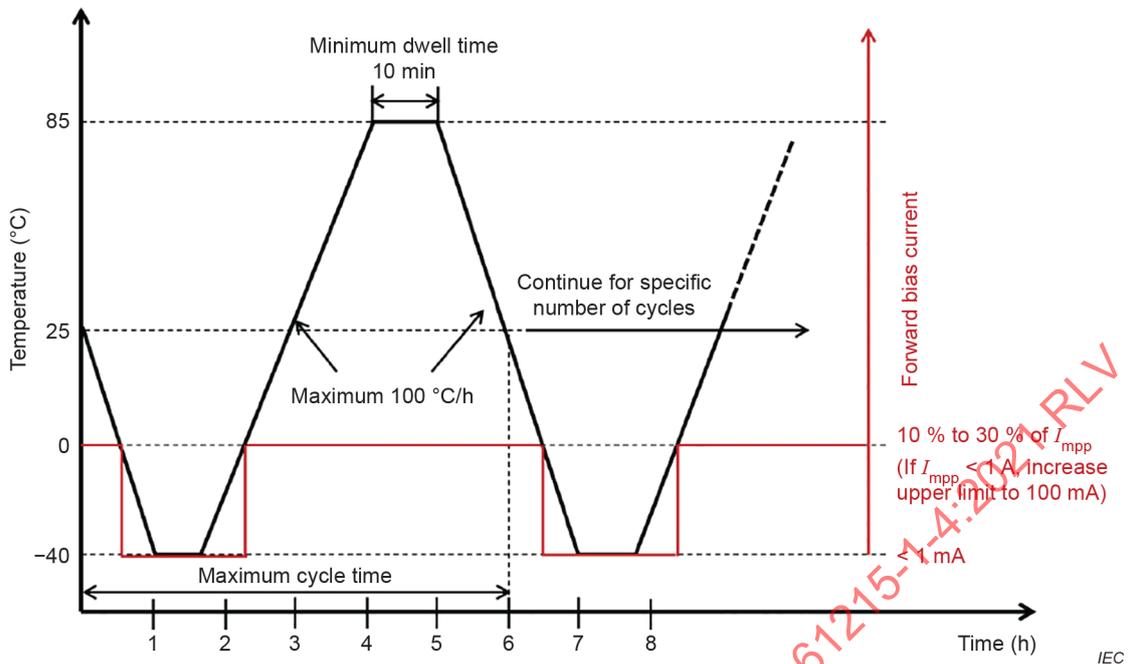
Method A) Perform MQT 11 as defined in IEC 61215-2:2021, with the technology specific current equal to  $0,1 \times$  STC peak power current. If  $0,1 \times$  STC peak power current is less than 100 mA, then 100 mA may be applied instead.

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  $0,1 \times$  STC peak power current to  $0,3 \times$  STC peak power current. If  $0,1 \times$  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.



**Figure 1 – Current flow using MQT 11 Method B**

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

This test of IEC 61215-2:2016/2021 is applicable ~~without~~ 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 × STC peak power current to 0,3 × 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.

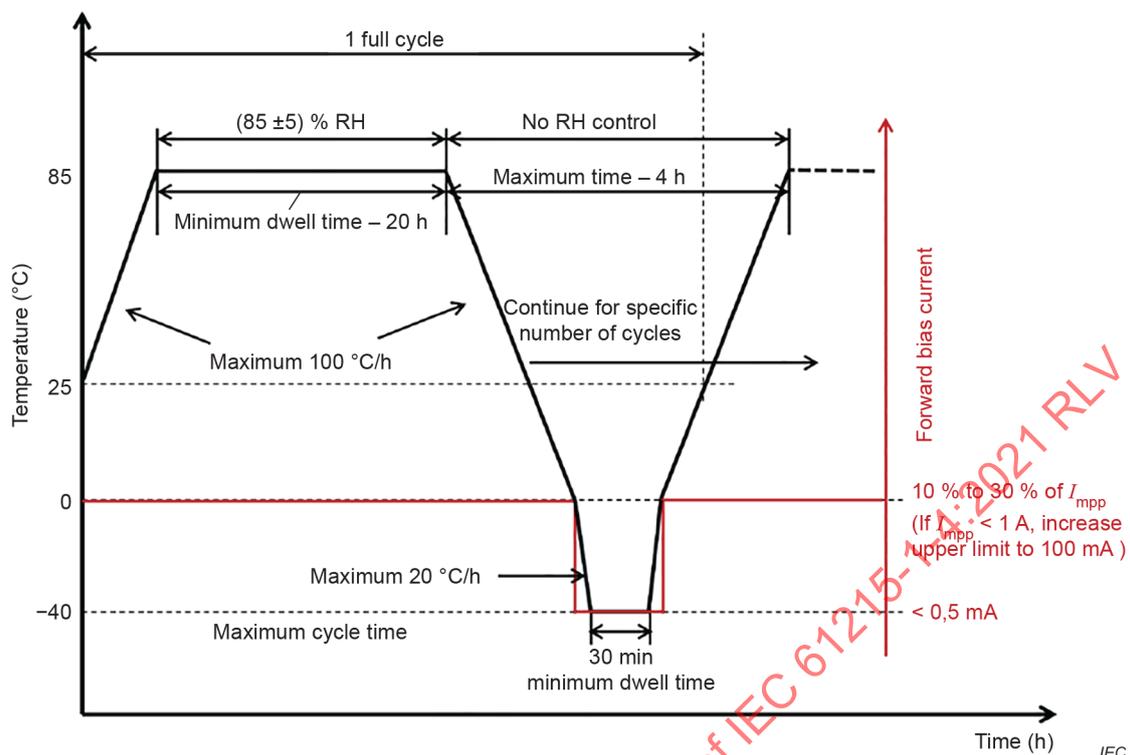


Figure 2 – Current flow using MQT 12 Method B

### 11.13 Damp heat test (MQT 13)

This test of IEC 61215-2:2016:2021 is applicable with the following modifications:

MQT 13 of IEC 61215-2:2016:2021 can be conducted according to the following methods:

Method A) Perform MQT 13 as defined in IEC 61215-2:2016:2021.

Method B) Perform MQT 13 as defined in IEC 61215-2:2016:2021 with applied forward bias:

#### 11.13.1 Procedure

- 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.
- 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.
- 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.
- Set chamber temperature to achieve a module temperature of  $85\text{ °C} \pm 2\text{ °C}$ .
- During cooling phase to ambient temperature ( $25\text{ °C}$  or less), the specified applied voltage shall be maintained and shall be switched off when the module temperature reaches  $25\text{ °C} \pm 5\text{ °C}$ .

**11.14 Robustness of terminations ~~test~~ (MQT 14)**

This test of IEC 61215-2:20162021 is applicable without modifications.

**11.15 Wet leakage current test (MQT 15)**

This test of IEC 61215-2:20162021 is applicable without modifications.

**11.16 Static mechanical load test (MQT 16)**

This test of IEC 61215-2:20162021 is applicable without modifications.

**11.17 Hail test (MQT 17)**

This test of IEC 61215-2:20162021 is applicable without modifications.

**11.18 Bypass diode testing (MQT 18)**

This test of IEC 61215-2:20162021 is applicable without modifications.

**11.19 Stabilization (MQT 19)**

This test of IEC 61215-2:20162021 is applicable with the following modifications:

**11.19.1 Criterion definition for stabilization**

For the definition of stabilization as per MQT 19 of IEC 61215-2:20162021,  $x = 0,02$  shall be used.

Any kind of storage shall be done at temperature below 25 °C to avoid thermally activated processes affecting MQT 06.1 of IEC 61215-2:20162021 measurement.

**11.19.2 Light induced stabilization procedures**

This test of IEC 61215-2:20162021 is applicable without modifications.

**11.19.3 Other stabilization procedures**

This test of IEC 61215-2:20162021 is applicable without modifications.

**11.19.4 Initial stabilization (MQT 19.1)**

Initial stabilization is performed on all modules.

To fulfil MQT 19 requirements using light exposure, a minimum of two intervals each of at least 10 kWh/m<sup>2</sup> are required. After this preconditioning all of the test modules shall be measured for STC power (MQT 06.1 of IEC 61215-2:20162021).

If stabilization is performed outdoors in general no module temperature limits apply. The outdoor stabilization shall be proven at least with one module using the indoor method following the validation procedure from MQT 19 of IEC 61215-2:20162021.

The minimum and maximum module temperatures observed during outdoor light exposure stabilization verification while the irradiance level is above 500 W/m<sup>2</sup> shall be the minimum and maximum allowable module temperatures for all modules. If the module temperature falls outside of these limits the new module temperature range has to be re-verified.

Output power determination shall be performed after a minimum cooling time of 30 min and maximum 60 min.

A validated alternative procedure can be used in accordance to MQT 19 of IEC 61215-2:2016/2021.

#### **11.19.5 Final stabilization (MQT 19.2)**

Final stabilization is performed on all modules after the test sequences to prove fulfilment of Gate No. 2 requirement of IEC 61215-1:2016/2021.

To fulfil MQT 19 requirements a minimum of two intervals of at least 10 kWh/m<sup>2</sup> each are required.

If stabilization is performed outdoors in general no module temperature limits apply. The outdoor stabilization shall be proven at least with one module using the indoor method following MQT 19 of IEC 61215-2:2016/2021.

The minimum and maximum module temperatures observed during outdoor light exposure stabilization verification while the irradiance level is above 500 W/m<sup>2</sup> shall be the minimum and maximum allowable module temperatures for all modules. If the module temperature falls outside of these limits the new module temperature range has to be re-verified.

For modules that have been subjected to potential induced degradation (PID) stress (MQT 21), the maximum exposure limit after reaching stabilization shall not be exceeded. The light soak shall terminate no more than 20 kWh/m<sup>2</sup> after the stabilization criterion is met.

Output power determination shall be performed after a minimum cooling time of 30 min and maximum 60 min.

A validated alternative procedure can be used in accordance to MQT 19 of IEC 61215-2:2016/2021.

#### **11.20 Cyclic (dynamic) mechanical load test (MQT 20)**

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

#### **11.21 Potential induced degradation test (MQT 21)**

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

MQT 21 of IEC 61215-2:2021 can be conducted according to either Method A or Method B below.

Method A) Perform MQT 21 as defined in IEC 61215-2:2021.

Method B) Perform MQT 21 as defined in IEC 61215-2:2021 with applied forward bias by adding the following steps to 4.21.4 "Procedure" in 61215-2:2021:

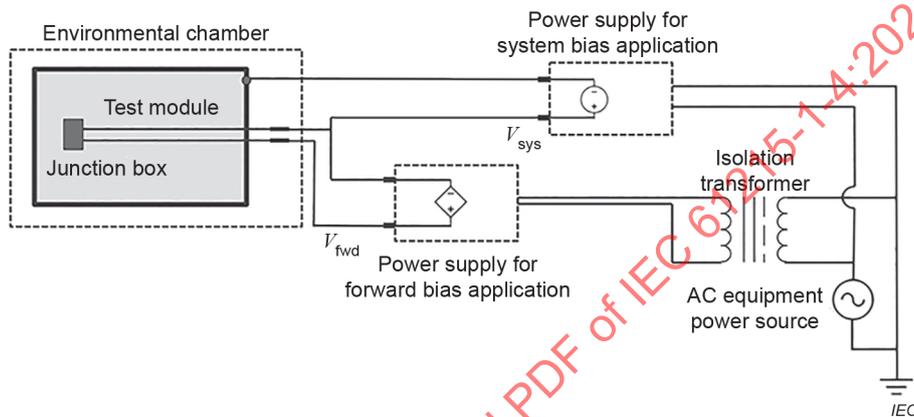
- a) Prior to the test, connect each module individually to the appropriate voltage supply. Proper lead connection is illustrated in Figure 3 and Figure 4.

In the positive system voltage configuration, the power supply for application of forward bias current is isolated by an isolation transformer and one DC terminal of the forward biasing power supply is connected to the system voltage terminal of the power supply for application of the system voltage bias (see Figure 3).

In the negative system voltage configuration, system voltage is applied to the normally grounded module frame, grounding, or mounting points and the power source for forward

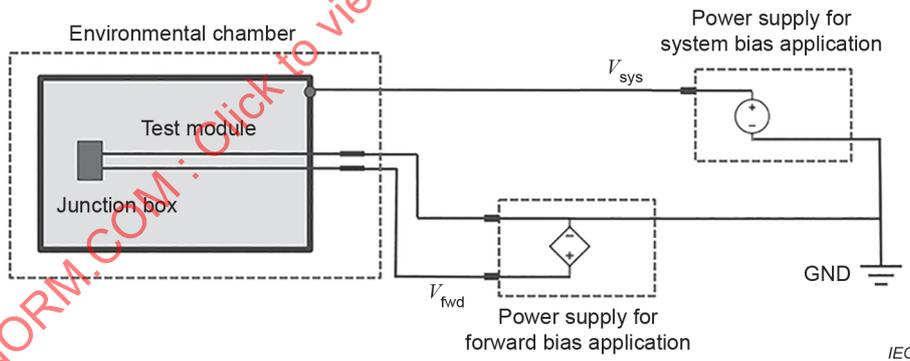
bias application has one DC terminal tied to ground (see Figure 4). The grounding points for the module shall be electrically isolated from the environmental chamber to prevent overloading of the power supply applying system voltage. A safety interlock that turns off the power supplies for the application of system voltage bias to the module frames is a requirement for safety for this configuration.

- b) During the test 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.
- d) During cooling phase to ambient temperature (25 °C or less), the specified applied voltage shall be maintained and shall be switched off when the module temperature reaches  $25\text{ °C} \pm 5\text{ °C}$ .



Schematic shows isolated power supply for application of forward bias ( $V_{fwd}$ ) and system voltage ( $V_{sys}$ ) applied to the active cell circuit.

**Figure 3 – Electrical connections for MQT 21 Method B, positive system voltage**



Schematic for application of system voltage ( $V_{sys}$ ) bias on test module on normally grounded parts. The system voltage applied to the active cell circuit is negative as shown and forward bias current is applied through the cell circuit.

**Figure 4 – Electrical connections for MQT 21 Method B, negative system voltage**

### 11.22 Bending test (MQT 22)

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

# INTERNATIONAL STANDARD

## NORME INTERNATIONALE



**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**

**Modules photovoltaïques (PV) pour applications terrestres – Qualification de la conception et homologation – Partie 1-4: Exigences particulières d'essai des modules photovoltaïques (PV) au Cu(In,Ga)(S,Se)<sub>2</sub> à couches minces**

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## 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**

## FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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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 International 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 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.

**IMPORTANT – The "colour inside" logo on the cover page of this document 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.**

# 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:

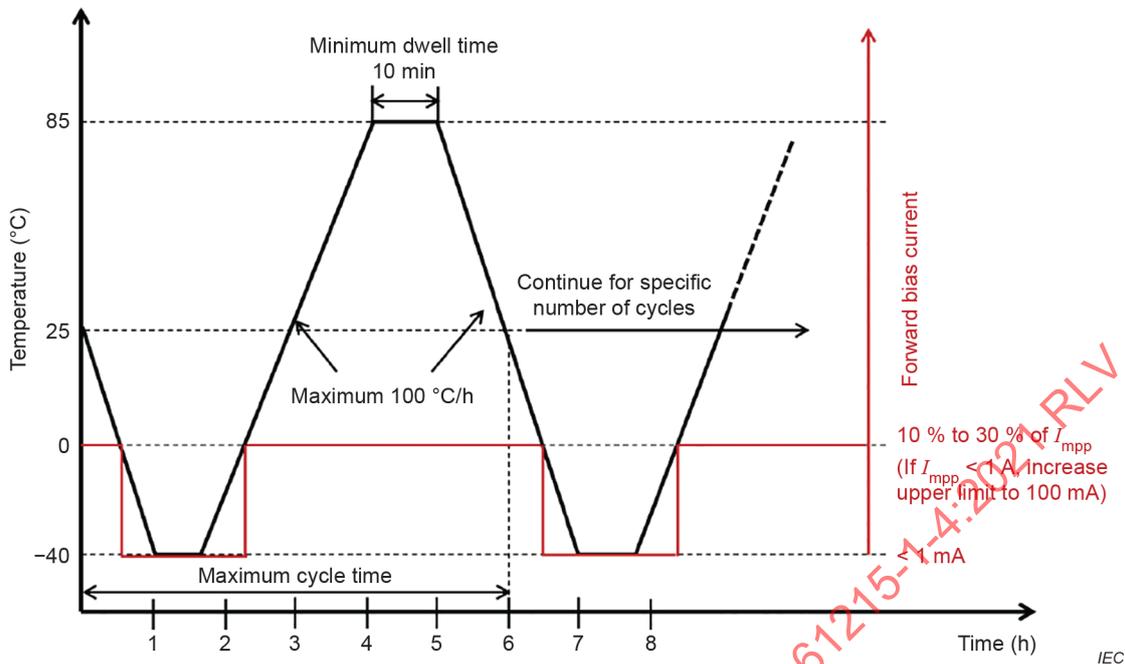
Method A) Perform MQT 11 as defined in IEC 61215-2:2021, with the technology specific current equal to  $0,1 \times$  STC peak power current. If  $0,1 \times$  STC peak power current is less than 100 mA, then 100 mA may be applied instead.

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  $0,1 \times$  STC peak power current to  $0,3 \times$  STC peak power current. If  $0,1 \times$  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.



**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  $0,1 \times$  STC peak power current to  $0,3 \times$  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.

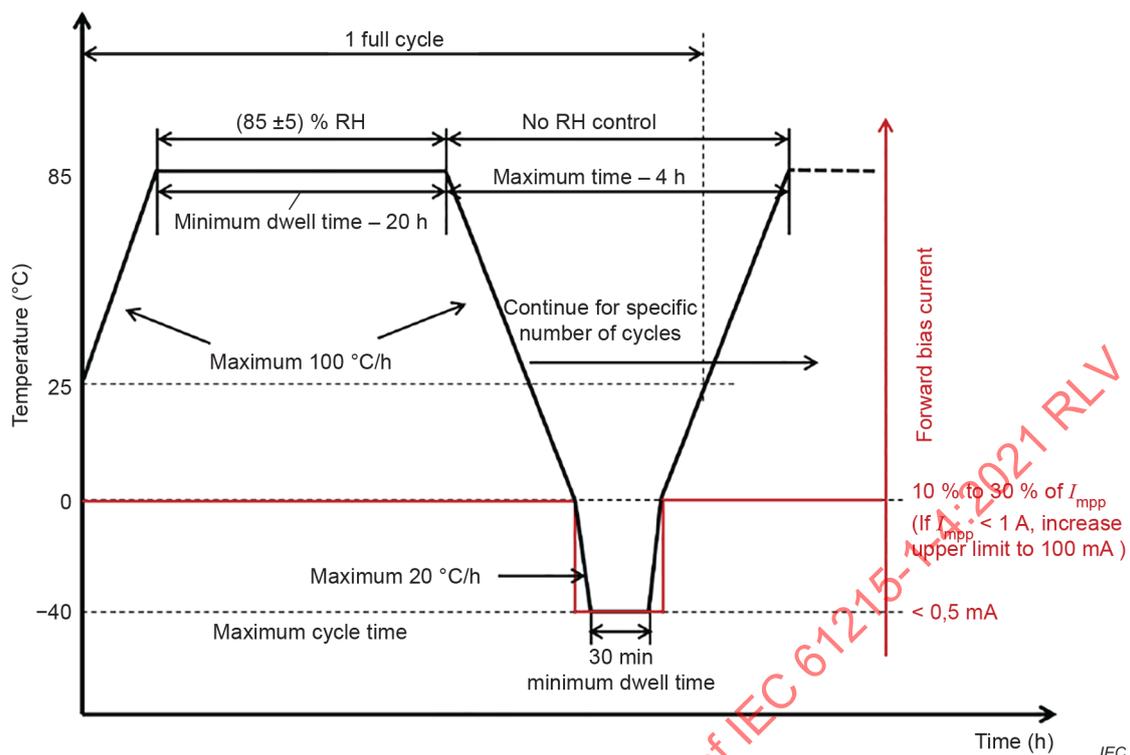


Figure 2 – Current flow using MQT 12 Method B

### 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

- 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.
- 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.
- 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.
- Set chamber temperature to achieve a module temperature of  $85\text{ °C} \pm 2\text{ °C}$ .
- During cooling phase to ambient temperature ( $25\text{ °C}$  or less), the specified applied voltage shall be maintained and shall be switched off when the module temperature reaches  $25\text{ °C} \pm 5\text{ °C}$ .

**11.14 Robustness of terminations (MQT 14)**

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

**11.15 Wet leakage current test (MQT 15)**

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

**11.16 Static mechanical load test (MQT 16)**

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

**11.17 Hail test (MQT 17)**

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

**11.18 Bypass diode testing (MQT 18)**

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

**11.19 Stabilization (MQT 19)**

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

**11.19.1 Criterion definition for stabilization**

For the definition of stabilization as per MQT 19 of IEC 61215-2:2021,  $x = 0,02$  shall be used.

Any kind of storage shall be done at temperature below 25 °C to avoid thermally activated processes affecting MQT 06.1 of IEC 61215-2:2021 measurement.

**11.19.2 Light induced stabilization procedures**

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

**11.19.3 Other stabilization procedures**

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

**11.19.4 Initial stabilization (MQT 19.1)**

Initial stabilization is performed on all modules.

To fulfil MQT 19 requirements using light exposure, a minimum of two intervals each of at least 10 kWh/m<sup>2</sup> are required. After this preconditioning all of the test modules shall be measured for STC power (MQT 06.1 of IEC 61215-2:2021).

If stabilization is performed outdoors in general no module temperature limits apply. The outdoor stabilization shall be proven at least with one module using the indoor method following the validation procedure from MQT 19 of IEC 61215-2:2021.

The minimum and maximum module temperatures observed during outdoor light exposure stabilization verification while the irradiance level is above 500 W/m<sup>2</sup> shall be the minimum and maximum allowable module temperatures for all modules. If the module temperature falls outside of these limits the new module temperature range has to be re-verified.

Output power determination shall be performed after a minimum cooling time of 30 min and maximum 60 min.

A validated alternative procedure can be used in accordance to MQT 19 of IEC 61215-2:2021.

#### **11.19.5 Final stabilization (MQT 19.2)**

Final stabilization is performed on all modules after the test sequences to prove fulfilment of Gate No. 2 requirement of IEC 61215-1:2021.

To fulfil MQT 19 requirements a minimum of two intervals of at least 10 kWh/m<sup>2</sup> each are required.

If stabilization is performed outdoors in general no module temperature limits apply. The outdoor stabilization shall be proven at least with one module using the indoor method following MQT 19 of IEC 61215-2:2021.

The minimum and maximum module temperatures observed during outdoor light exposure stabilization verification while the irradiance level is above 500 W/m<sup>2</sup> shall be the minimum and maximum allowable module temperatures for all modules. If the module temperature falls outside of these limits the new module temperature range has to be re-verified.

For modules that have been subjected to potential induced degradation (PID) stress (MQT 21), the maximum exposure limit after reaching stabilization shall not be exceeded. The light soak shall terminate no more than 20 kWh/m<sup>2</sup> after the stabilization criterion is met.

Output power determination shall be performed after a minimum cooling time of 30 min and maximum 60 min.

A validated alternative procedure can be used in accordance to MQT 19 of IEC 61215-2:2021.

#### **11.20 Cyclic (dynamic) mechanical load test (MQT 20)**

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

#### **11.21 Potential induced degradation test (MQT 21)**

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

MQT 21 of IEC 61215-2:2021 can be conducted according to either Method A or Method B below.

Method A) Perform MQT 21 as defined in IEC 61215-2:2021.

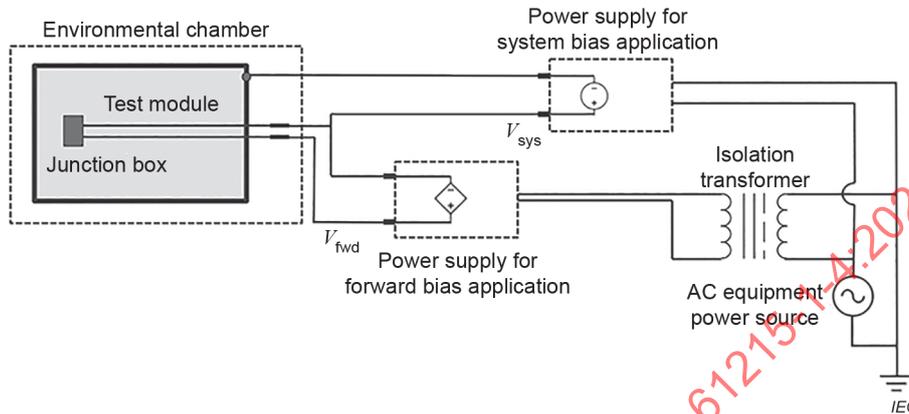
Method B) Perform MQT 21 as defined in IEC 61215-2:2021 with applied forward bias by adding the following steps to 4.21.4 "Procedure" in 61215-2:2021:

- a) Prior to the test, connect each module individually to the appropriate voltage supply. Proper lead connection is illustrated in Figure 3 and Figure 4.

In the positive system voltage configuration, the power supply for application of forward bias current is isolated by an isolation transformer and one DC terminal of the forward biasing power supply is connected to the system voltage terminal of the power supply for application of the system voltage bias (see Figure 3).

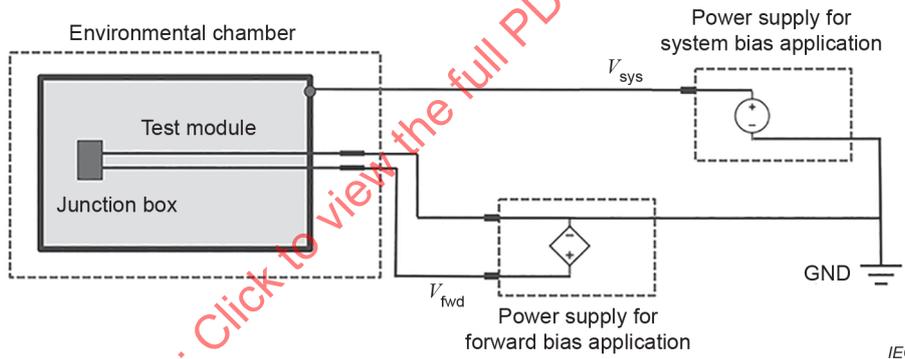
In the negative system voltage configuration, system voltage is applied to the normally grounded module frame, grounding, or mounting points and the power source for forward bias application has one DC terminal tied to ground (see Figure 4). The grounding points for the module shall be electrically isolated from the environmental chamber to prevent overloading of the power supply applying system voltage. A safety interlock that turns off the power supplies for the application of system voltage bias to the module frames is a requirement for safety for this configuration.

- b) During the test 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.
- d) During cooling phase to ambient temperature (25 °C or less), the specified applied voltage shall be maintained and shall be switched off when the module temperature reaches  $25\text{ °C} \pm 5\text{ °C}$ .



Schematic shows isolated power supply for application of forward bias ( $V_{fwd}$ ) and system voltage ( $V_{sys}$ ) applied to the active cell circuit.

**Figure 3 – Electrical connections for MQT 21 Method B, positive system voltage**



Schematic for application of system voltage ( $V_{sys}$ ) bias on test module on normally grounded parts. The system voltage applied to the active cell circuit is negative as shown and forward bias current is applied through the cell circuit.

**Figure 4 – Electrical connections for MQT 21 Method B, negative system voltage**

### 11.22 Bending test (MQT 22)

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

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## COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

**MODULES PHOTOVOLTAÏQUES (PV) POUR APPLICATIONS  
TERRESTRES – QUALIFICATION DE LA CONCEPTION ET  
HOMOLOGATION –****Partie 1-4: Exigences particulières d'essai  
des modules photovoltaïques (PV)  
au  $\text{Cu(In,Ga)(S,Se)}_2$  à couches minces**

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La Norme internationale IEC 61215-1-4 a été établie par le comité d'études 82 de l'IEC: Systèmes de conversion photovoltaïque de l'énergie solaire.

Cette deuxième édition annule et remplace la première édition de l'IEC 61215-1-4, parue en 2016. Cette édition constitue une révision technique.

Cette édition inclut les modifications techniques majeures suivantes par rapport à l'édition précédente:

- a) Ajout d'un essai de charge mécanique (dynamique) cyclique (MQT 20).
- b) Ajout d'un essai de dégradation induite par le potentiel (MQT 21).
- c) Ajout d'un essai de flexion (MQT 22) dédié aux modules souples.

L'Annexe informative A de l'IEC 61215-1:2021 explique le contexte et le raisonnement qui justifient certaines modifications les plus importantes apportées à la série IEC 61215 dans l'évolution de l'édition 1 à l'édition 2.

Le texte de cette norme est issu des documents suivants:

FDIS	Rapport de vote
82/1827/FDIS	82/1852/RVD

Le rapport de vote indiqué dans le tableau ci-dessus donne toute information sur le vote ayant abouti à l'approbation de cette Norme internationale.

La version française de la norme n'a pas été soumise au vote.

Ce document a été rédigé selon les Directives ISO/IEC, Partie 2.

La présente norme doit être utilisée conjointement avec l'IEC 61215-1:2021 et l'IEC 61215-2:2021.

Une liste de toutes les parties de la série IEC 61215, publiées sous le titre général *Modules photovoltaïques (PV) pour applications terrestres – Qualification de la conception et homologation*, peut être consultée sur le site web de l'IEC.

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# MODULES PHOTOVOLTAÏQUES (PV) POUR APPLICATIONS TERRESTRES – QUALIFICATION DE LA CONCEPTION ET HOMOLOGATION –

## Partie 1-4: Exigences particulières d'essai des modules photovoltaïques (PV) au $\text{Cu(In,Ga)(S,Se)}_2$ à couches minces

### 1 Domaine d'application

Le présent document établit les exigences pour la qualification de la conception des modules photovoltaïques (PV) pour applications terrestres adaptés à une utilisation de longue durée dans les climats à l'air libre. La durée de vie utile des modules ainsi qualifiés dépend de leur conception, de leur environnement et de leurs conditions de fonctionnement. Les résultats d'essai ne sont pas considérés comme une prévision quantitative de la durée de vie des modules.

Sous des climats pour lesquels les températures de fonctionnement du 98<sup>e</sup> percentile dépassent 70 °C, il est recommandé aux utilisateurs d'envisager d'effectuer des essais dans des conditions d'essai à des températures plus élevées telles que décrites dans l'IEC TS 63126. Il est recommandé aux utilisateurs qui souhaitent qualifier des produits PV ayant une durée de vie moins longue d'envisager des essais conçus pour des produits PV utilisés dans l'électronique grand public, comme cela est spécifié dans l'IEC 63163 (en cours d'élaboration). Les utilisateurs qui souhaitent être assurés qu'un produit fabriqué présente de manière cohérente les caractéristiques soumises aux essais dans le cadre de l'IEC 61215 peuvent vouloir utiliser l'IEC 62941 relative aux systèmes de qualité pour la fabrication des modules photovoltaïques (PV).

Le présent document est destiné à s'appliquer à tous les modules à plaque plane au  $\text{Cu(In,Ga)(S,Se)}_2$  à couches minces pour applications terrestres. À ce titre, il spécifie des exigences d'essai particulières à cette technologie en complément des exigences d'essai données dans l'IEC 61215-1:2021 et l'IEC 61215-2:2021.

Le présent document ne s'applique pas aux modules utilisés avec un ensoleillement intense, même s'il peut être utilisé pour les modules à faible concentration (ensoleillement 1 à 3). Pour les modules à faible concentration, tous les essais sont réalisés en utilisant les niveaux d'éclairement, de courant, de tension et de puissance prévus à la concentration théorique.

L'objet de cette séquence d'essais est de déterminer les caractéristiques électriques du module et de démontrer, dans toute la mesure du possible et avec des contraintes de coût et de temps raisonnables, que le module est capable de supporter une exposition prolongée en site naturel. Les conditions d'essais accélérés sont fondées de manière empirique sur les conditions nécessaires pour reproduire les défaillances sur site observées sélectionnées et sont appliquées de manière égale aux types de modules. Les facteurs d'accélération peuvent varier avec la conception du produit et ainsi les mécanismes de dégradation peuvent ne pas tous se produire. D'autres informations générales concernant les méthodes d'essais accélérés, y compris les définitions des termes, peuvent être consultées dans l'IEC 62506.

Certains mécanismes de dégradation de longue durée ne peuvent être raisonnablement détectés que par des essais de composants, en raison des longs délais exigés pour produire la défaillance et de l'existence nécessaire de conditions de contrainte dont la réalisation est coûteuse sur de grandes surfaces. Les essais de composants qui ont atteint un niveau de maturité suffisant pour établir des critères d'acceptation/refus en toute fiabilité sont intégrés dans la série IEC 61215 par le biais d'un ajout dans le Tableau 1 de l'IEC 61215-1. En

revanche, les procédures d'essai décrites dans cette série IEC 61215-2, sont réalisées sur des modules.

Le présent document définit les modifications dépendantes de la technologie photovoltaïque, apportées aux exigences et procédures d'essai de l'IEC 61215-1:2021 et de l'IEC 61215-2:2021.

## 2 Références normatives

Les références normatives de l'IEC 61215-1:2021 et de l'IEC 61215-2:2021 s'appliquent sans modification.

## 3 Termes et définitions

Cet article de l'IEC 61215-1:2021 s'applique sans modification.

## 4 Échantillons d'essai

Cet article de l'IEC 61215-1:2021 s'applique sans modification.

## 5 Marquage et documentation

Cet article de l'IEC 61215-1:2021 s'applique sans modification.

## 6 Essais

Cet article de l'IEC 61215-1:2021 s'applique avec les modifications suivantes:

Une attention particulière doit être accordée à la stabilisation de la puissance de sortie du module dans le cadre de la procédure MQT 19, conformément aux exigences spécifiques données en 11.19 ci-après.

## 7 Critères d'acceptation

Cet article de l'IEC 61215-1:2021 s'applique avec les modifications suivantes:

La valeur maximale admissible de reproductibilité est fixée à  $r = 2,0 \%$ .

La valeur maximale admissible de l'incertitude de mesure est fixée à  $m_1 = 4,0 \%$  pour les modules contenant des cellules à jonction unique, et à  $m_1 = 5,0 \%$  pour les modules contenant des cellules multijonctions.

## 8 Défauts visuels majeurs

Cet article de l'IEC 61215-1:2021 s'applique sans modification.

## 9 Rapport

Cet article de l'IEC 61215-1:2021 s'applique sans modification.

## 10 Modifications

Cet article de l'IEC 61215-1:2021 s'applique sans modification.

## 11 Série et procédures d'essais

La série d'essais de l'IEC 61215-1:2021 s'applique.

### 11.1 Examen visuel (MQT 01)

Cet essai de l'IEC 61215-2:2021 s'applique sans modification.

### 11.2 Détermination de la puissance maximale (MQT 02)

Cet essai de l'IEC 61215-2:2021 s'applique sans modification.

### 11.3 Essai diélectrique (MQT 03)

Cet essai de l'IEC 61215-2:2021 s'applique sans modification.

### 11.4 Mesurage des coefficients de température (MQT 04)

Cet essai de l'IEC 61215-2:2021 s'applique sans modification.

### 11.5 Section de l'espace réservé, précédemment NMOT

Ce paragraphe de l'IEC 61215-2:2021 n'exige pas de modifications spécifiques à la technologie.

### 11.6 Performances dans les STC (MQT 06.1)

Cet essai de l'IEC 61215-2:2021 s'applique sans modification.

### 11.7 Performances sous faible éclairage (MQT 07)

Cet essai de l'IEC 61215-2:2021 s'applique sans modification.

### 11.8 Essai d'exposition en site naturel (MQT 08)

Cet essai de l'IEC 61215-2:2021 s'applique sans modification.

### 11.9 Essai de tenue à l'échauffement localisé (MQT 09)

Cet essai de l'IEC 61215-2:2021 s'applique avec les modifications suivantes:

Les modules au  $\text{Cu(In,Ga)(S,Se)}_2$  à couches minces peuvent présenter des variations de performances après un stockage prolongé dans l'obscurité ("phénomène de stockage prolongé à l'abri de la lumière"). Afin de réduire le plus possible l'influence de ce phénomène de stockage prolongé à l'abri de la lumière, limiter le délai entre l'exposition en site naturel ou la stabilisation et la procédure d'échauffement localisé à 2 à 3 jours. Au cours de la première heure suivant l'achèvement de la procédure d'échauffement localisé, aucun chauffage ni aucune lumière supplémentaire au-delà des conditions ambiantes du local ne doivent être appliqués. Si le délai doit dépasser 1 h; les modules doivent être stockés dans l'obscurité à une température  $\leq 25^\circ\text{C}$ .

#### 11.9.1 Objet

Ce paragraphe de l'IEC 61215-2:2021, essai MQT 09, s'applique sans modification.