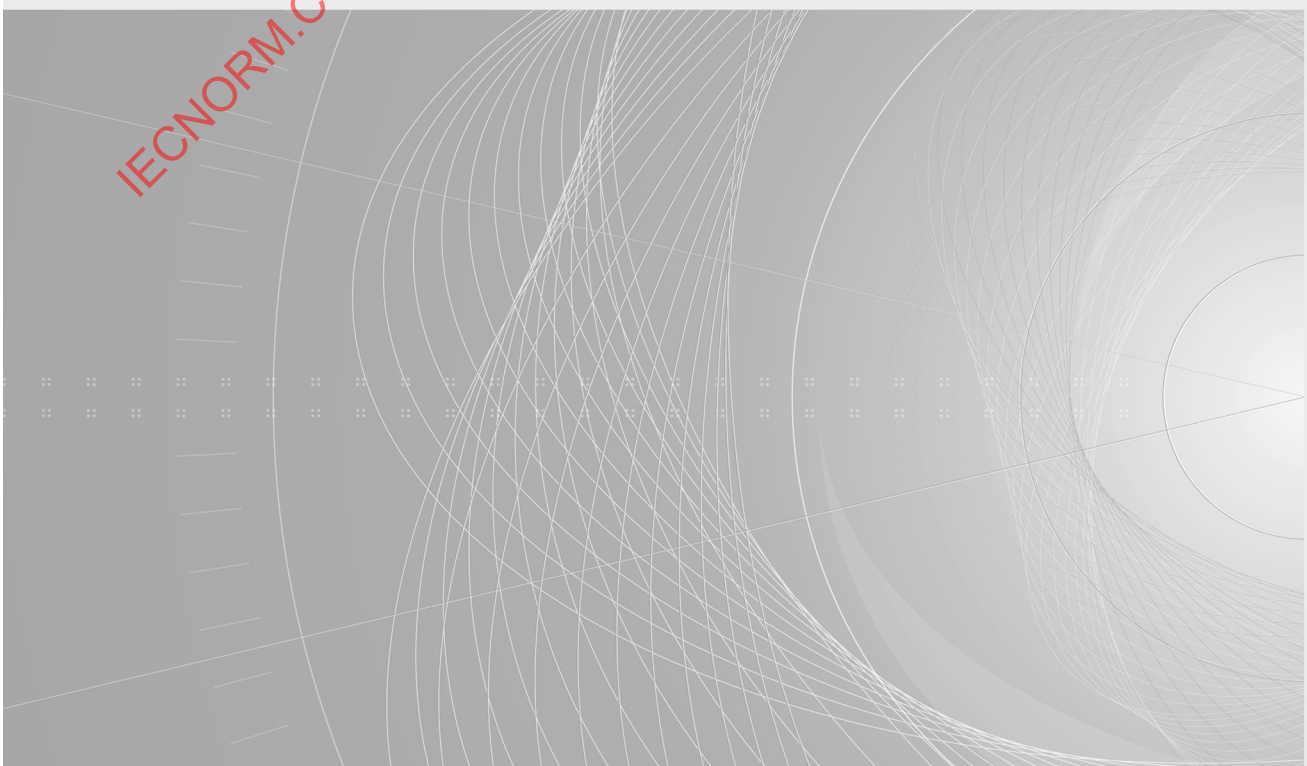
IEC 61215-1-4

Edition 2.0 2021-02
REDLINE VERSION

INTERNATIONAL STANDARD

colour inside

Terrestrial photovoltaic (PV) modules – Design qualification and type approval – Part 1-4: Special requirements for testing of thin-film Cu(In,Ga)(S,Se)$_2$ based photovoltaic (PV) modules



IEC 61215-1-4:2021-02 RLV(en)

IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

About the IEC
The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications
The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigendum or an amendment might have been published.

IEC publications search - webstore.iec.ch/advsearchform
The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee, …). It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished
Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and once a month by email.

IEC Customer Service Centre - webstore.iec.ch/csc
If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: sales@iec.ch.

IEC online collection - oc.iec.ch
Discover our powerful search engine and read freely all the publications previews. With a subscription you will always have access to up to date content tailored to your needs.

Electropedia - www.electropedia.org
The world's leading online dictionary on electrotechnology, containing more than 22 000 terminological entries in English and French, with equivalent terms in 18 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

IEC 61215-1-4

Edition 2.0 2021-02
REDLINE VERSION

INTERNATIONAL STANDARD

colour inside

Terrestrial photovoltaic (PV) modules – Design qualification and type approval – Part 1-4: Special requirements for testing of thin-film Cu(In,Ga)(S,Se)$_2$ based photovoltaic (PV) modules

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 27.160

ISBN 978-2-8322-9489-5

CONTENTS

FOREWORD 4
1 Scope ~~and object~~ 6
2 Normative references 7
3 Terms and definitions 7
4 Test samples 7
5 Marking and documentation 7
6 Testing 7
7 Pass criteria 7
8 Major visual defects 7
9 Report 7
10 Modifications 7
11 Test flow and procedures 8
11.1 Visual inspection (MQT 01) 8
11.2 Maximum power determination (MQT 02) 8
11.3 Insulation test (MQT 03) 8
11.4 Measurement of temperature coefficients (MQT 04) 8
11.5 ~~Measurement of nominal module operating temperature (NMOT) (MQT 05)~~ Placeholder section, formerly NMOT 8
11.6 Performance at STC (MQT 06.1) ~~and NMOT (MQT 06.2)~~ 8
11.7 Performance at low irradiance (MQT 07) 8
11.8 Outdoor exposure test (MQT 08) 8
11.9 Hot-spot endurance test (MQT 09) 8
11.9.1 Purpose 8
11.9.2 Hot-spot effect 8
11.9.3 Classification of cell interconnection 9
11.9.4 Apparatus 9
11.9.5 Procedure 9
11.9.6 Final measurements 9
11.9.7 Requirements 9
11.10 UV preconditioning test (MQT 10) 9
11.11 Thermal cycling test (MQT 11) 9
11.12 Humidity-freeze test (MQT 12) 9
11.13 Damp heat test (MQT 13) 11
11.13.1 Procedure 11
11.14 Robustness of terminations ~~test~~ (MQT 14) 12
11.15 Wet leakage current test (MQT 15) 12
11.16 Static mechanical load test (MQT 16) 12
11.17 Hail test (MQT 17) 12
11.18 Bypass diode testing (MQT 18) 12
11.19 Stabilization (MQT 19) 12
11.19.1 Criterion definition for stabilization 12
11.19.2 Light induced stabilization procedures 12
11.19.3 Other stabilization procedures 12
11.19.4 Initial stabilization (MQT 19.1) 12
11.19.5 Final stabilization (MQT 19.2) 13

11.20 Cyclic (dynamic) mechanical load test (MQT 20) 13
11.21 Potential induced degradation test (MQT 21) 13
11.22 Bending test (MQT 22) 14

Figure 1 – Current flow using MQT 11 Method B 10
Figure 2 – Current flow using MQT 12 Method B 11
Figure 3 – Electrical connections for MQT 21 Method B, positive system voltage 14
Figure 4 – Electrical connections for MQT 21 Method B, negative system voltage 14

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)$_2$ 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.
2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
6) All users should ensure that they have the latest edition of this publication.
7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

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.

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)$_2$ 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 98th 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)$_2$ 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:~~2016~~2021 and IEC 61215-2:~~2016~~2021.

2 Normative references

The normative references of IEC 61215-1:~~2016~~2021 and IEC 61215-2:~~2016~~2021 are applicable without modifications.

3 Terms and definitions

This clause of IEC 61215-1:~~2016~~2021 is applicable without modifications.

4 Test samples

This clause of IEC 61215-1:~~2016~~2021 is applicable without modifications.

5 Marking and documentation

This clause of IEC 61215-1:~~2016~~2021 is applicable without modifications.

6 Testing

This clause of IEC 61215-1:~~2016~~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:~~2016~~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:~~2016~~2021 is applicable without modifications.

9 Report

This clause of IEC 61215-1:~~2016~~2021 is applicable without modifications.

10 Modifications

This clause of IEC 61215-1:~~2016~~2021 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:

$Cu(In,Ga)(S,Se)_2$ 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 × 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 × STC peak power current. If 0,1 × 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 × STC peak power current to 0,3 × STC peak power current. If 0,1 × 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.

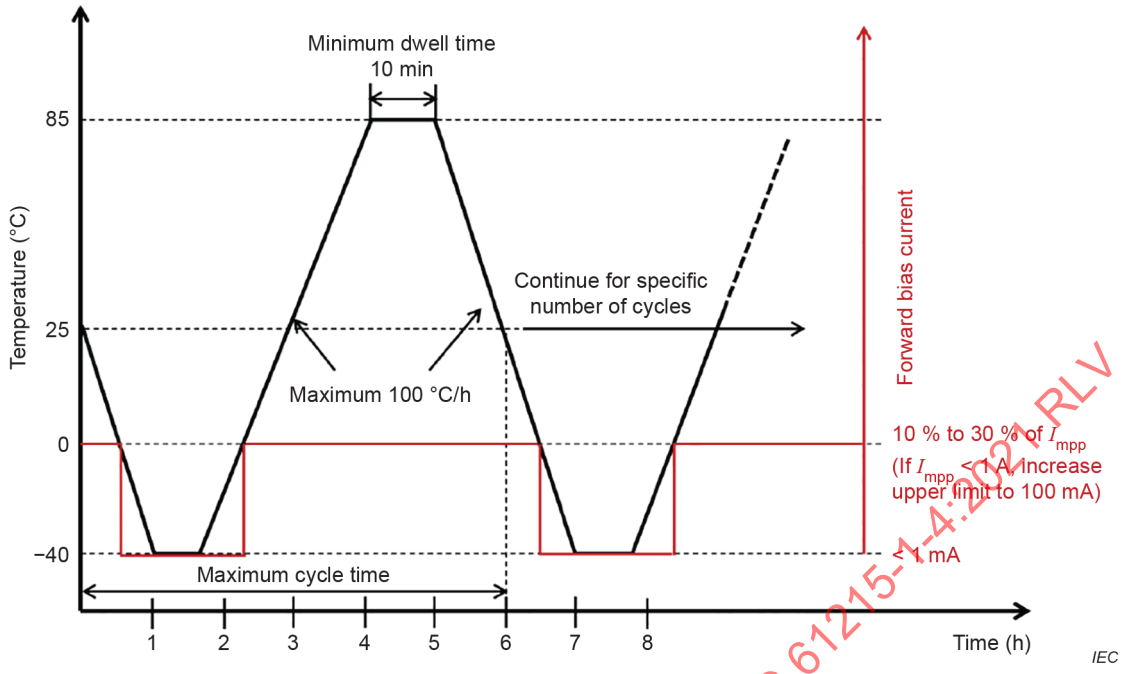


Figure 1 – Current flow using MQT 11 Method B

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.

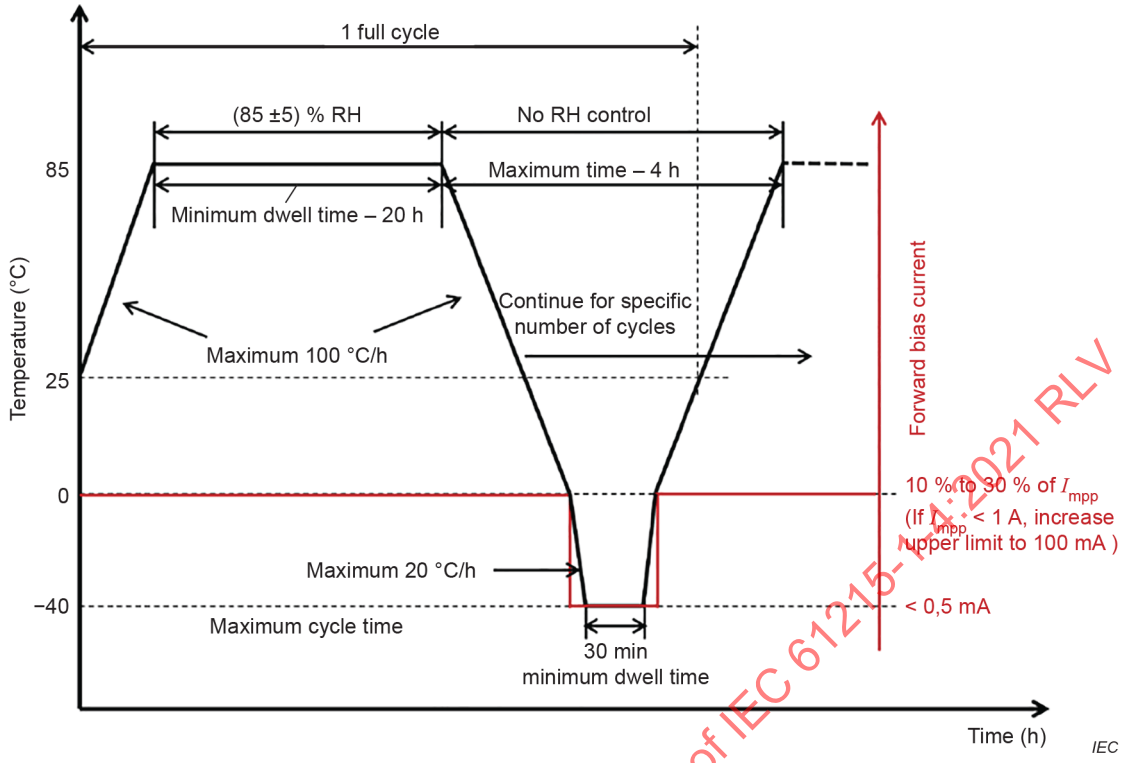


Figure 2 – Current flow using MQT 12 Method B

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

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} ± 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} ± 5 % at STC.

d) Set chamber temperature to achieve a module temperature of 85 °C ± 2 °C.

e) 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 °C ± 5 °C.

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

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

11.15 Wet leakage current test (MQT 15)

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

11.16 Static mechanical load test (MQT 16)

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

11.17 Hail test (MQT 17)

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

11.18 Bypass diode testing (MQT 18)

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

11.19 Stabilization (MQT 19)

This test of IEC 61215-2:~~2016~~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:~~2016~~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:~~2016~~2021 measurement.

11.19.2 Light induced stabilization procedures

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

11.19.3 Other stabilization procedures

This test of IEC 61215-2:~~2016~~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^2 are required. After this preconditioning all of the test modules shall be measured for STC power (MQT 06.1 of IEC 61215-2:~~2016~~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:~~2016~~2021.

The minimum and maximum module temperatures observed during outdoor light exposure stabilization verification while the irradiance level is above 500 W/m^2 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^2 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^2 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^2 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).

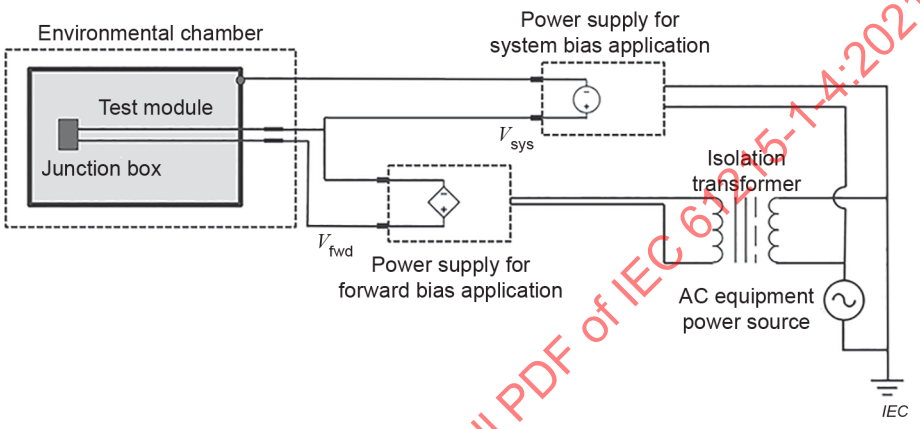
   In the negative system voltage configuration, system voltage is applied to the normally grounded module frame, grounding, or mounting points and the power source for forward

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} ± 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.

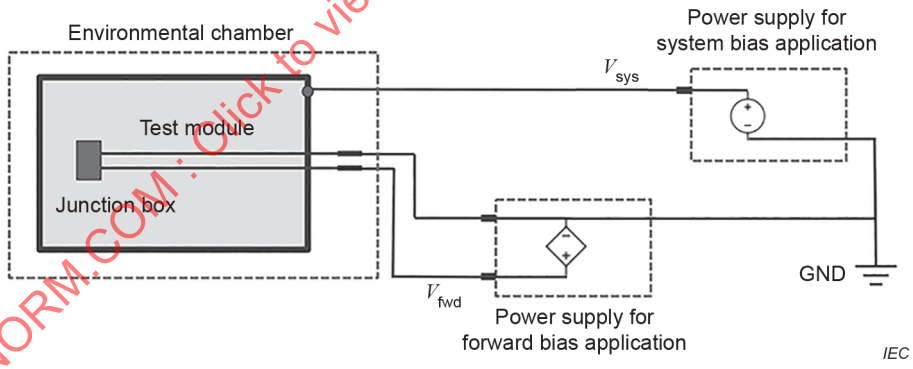
c) Throughout the test monitor the module's applied voltage and current. Report I-V trend. If current limit is reached, applied voltage can drop below V_{mpp} ± 5 % at STC.

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 °C ± 5 °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.

IEC 61215-1-4

Edition 2.0 2021-02

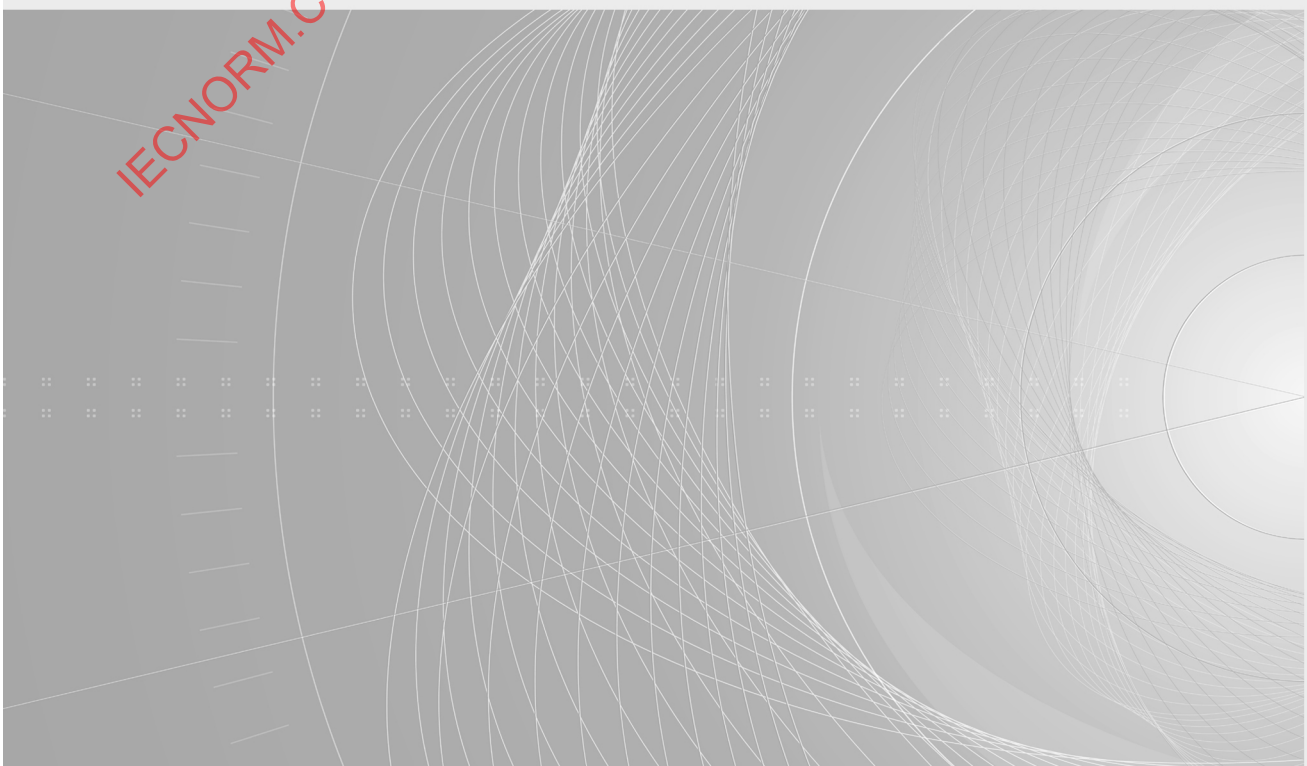
INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

Terrestrial photovoltaic (PV) modules – Design qualification and type approval – Part 1-4: Special requirements for testing of thin-film Cu(In,Ga)(S,Se)$_2$ 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)$_2$ à couches minces



IEC 61215-1-4:2021-02(en-fr)

CONTENTS

FOREWORD 4
1 Scope 6
2 Normative references 6
3 Terms and definitions 7
4 Test samples 7
5 Marking and documentation 7
6 Testing 7
7 Pass criteria 7
8 Major visual defects 7
9 Report 7
10 Modifications 7
11 Test flow and procedures 7
11.1 Visual inspection (MQT 01) 7
11.2 Maximum power determination (MQT 02) 7
11.3 Insulation test (MQT 03) 8
11.4 Measurement of temperature coefficients (MQT 04) 8
11.5 Placeholder section, formerly NMOT 8
11.6 Performance at STC (MQT 06.1) 8
11.7 Performance at low irradiance (MQT 07) 8
11.8 Outdoor exposure test (MQT 08) 8
11.9 Hot-spot endurance test (MQT 09) 8
11.9.1 Purpose 8
11.9.2 Hot-spot effect 8
11.9.3 Classification of cell interconnection 8
11.9.4 Apparatus 8
11.9.5 Procedure 8
11.9.6 Final measurements 9
11.9.7 Requirements 9
11.10 UV preconditioning test (MQT 10) 9
11.11 Thermal cycling test (MQT 11) 9
11.12 Humidity-freeze test (MQT 12) 10
11.13 Damp heat test (MQT 13) 11
11.13.1 Procedure 11
11.14 Robustness of terminations (MQT 14) 12
11.15 Wet leakage current test (MQT 15) 12
11.16 Static mechanical load test (MQT 16) 12
11.17 Hail test (MQT 17) 12
11.18 Bypass diode testing (MQT 18) 12
11.19 Stabilization (MQT 19) 12
11.19.1 Criterion definition for stabilization 12
11.19.2 Light induced stabilization procedures 12
11.19.3 Other stabilization procedures 12
11.19.4 Initial stabilization (MQT 19.1) 12
11.19.5 Final stabilization (MQT 19.2) 13
11.20 Cyclic (dynamic) mechanical load test (MQT 20) 13

11.21 Potential induced degradation test (MQT 21) 13
11.22 Bending test (MQT 22) 14

Figure 1 – Current flow using MQT 11 Method B 10
Figure 2 – Current flow using MQT 12 Method B 11
Figure 3 – Electrical connections for MQT 21 Method B, positive system voltage 14
Figure 4 – Electrical connections for MQT 21 Method B, negative system voltage 14

INTERNATIONAL ELECTROTECHNICAL COMMISSION

_____

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

Part 1-4: Special requirements for testing of thin-film $Cu(In,Ga)(S,Se)_2$ 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.
2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
6) All users should ensure that they have the latest edition of this publication.
7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

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 $Cu(In,Ga)(S,Se)_2$ 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 98th 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 $Cu(In,Ga)(S,Se)_2$ 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:

$Cu(In,Ga)(S,Se)_2$ 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 × STC peak power current. If 0,1 × 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 × STC peak power current to 0,3 × STC peak power current. If 0,1 × 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.

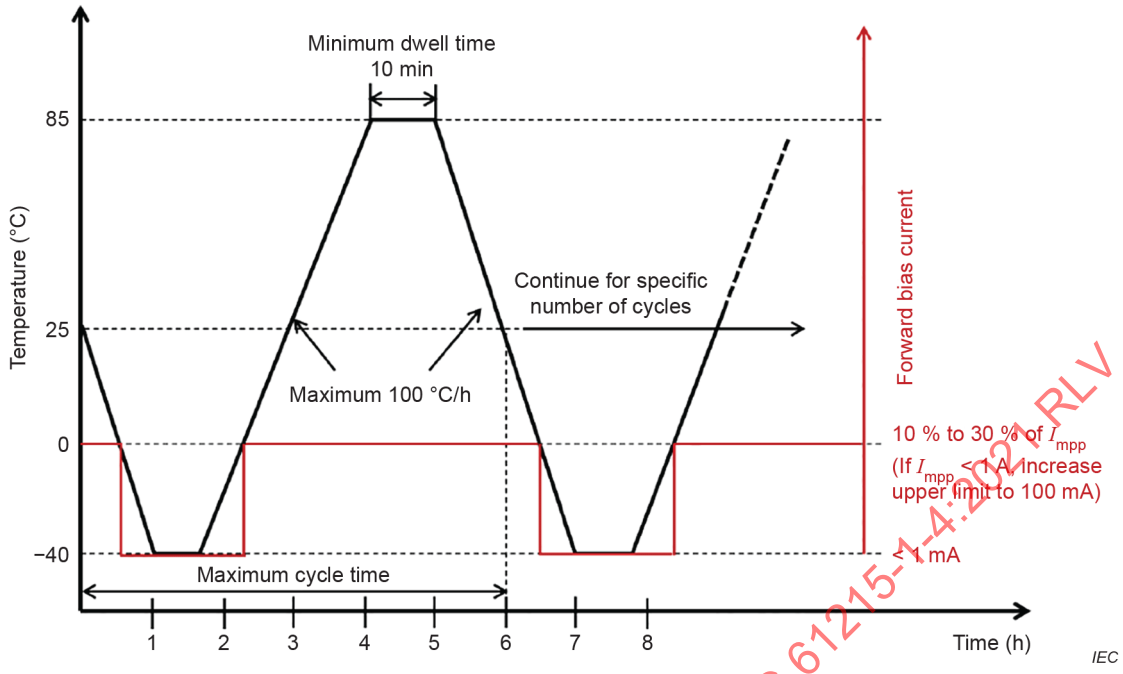


Figure 1 – Current flow using MQT 11 Method B

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 × 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.

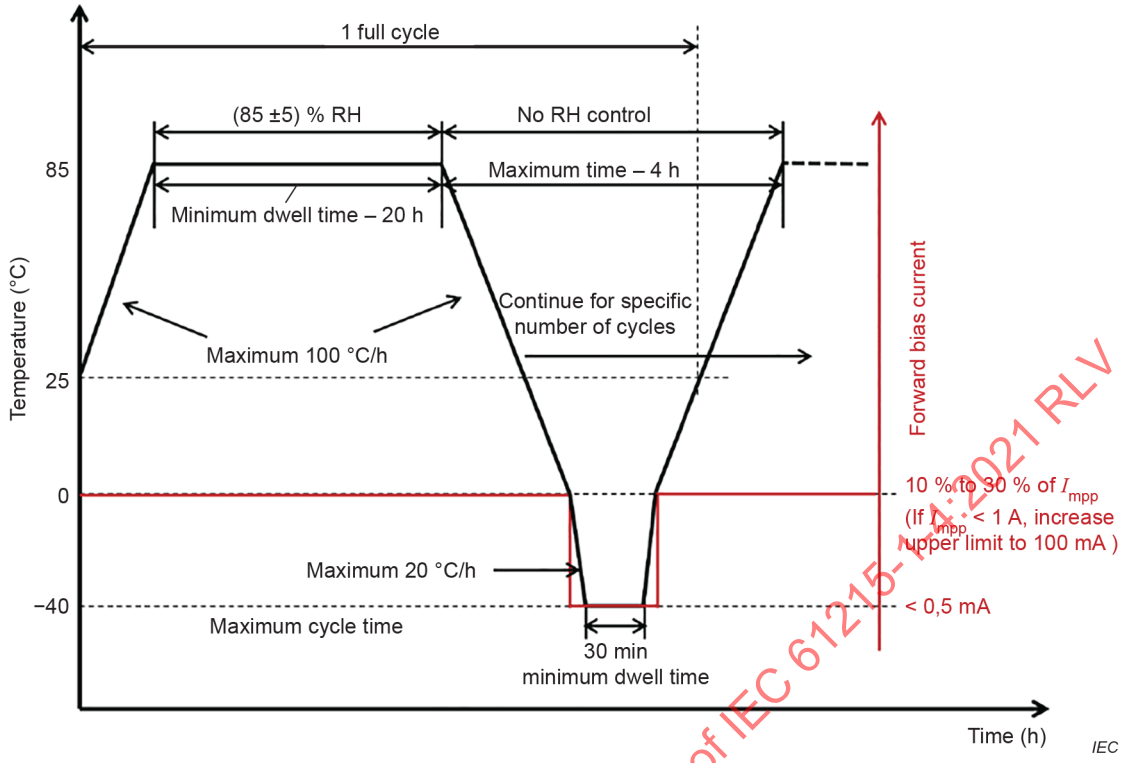


Figure 2 – Current flow using MQT 12 Method B

11.13 Damp heat test (MQT 13)

This test of IEC 61215-2:2021 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} ± 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} ± 5 % at STC.

d) Set chamber temperature to achieve a module temperature of 85 °C ± 2 °C.

e) 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 °C ± 5 °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^2 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^2 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^2 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^2 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^2 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.

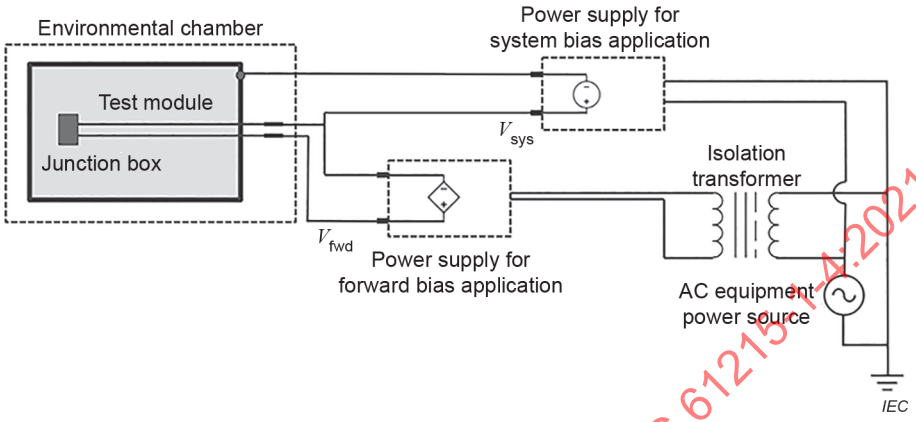
   In the positive system voltage configuration, the power supply for application of forward bias current is isolated by an isolation transformer and one DC terminal of the forward biasing power supply is connected to the system voltage terminal of the power supply for application of the system voltage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

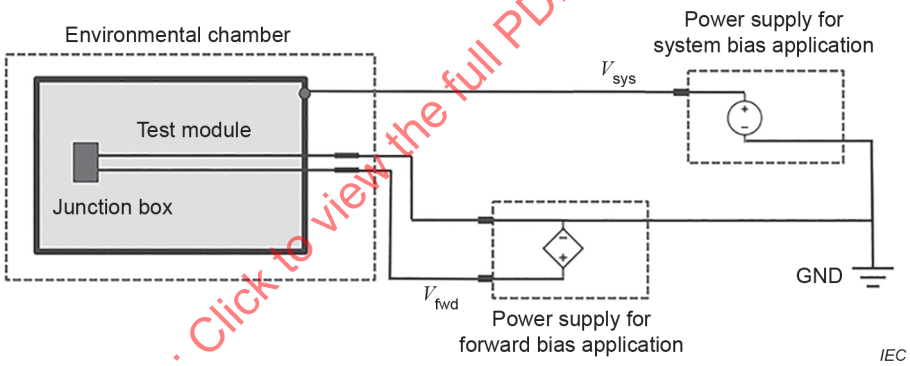
c) Throughout the test monitor the module's applied voltage and current. Report I-V trend. If current limit is reached, applied voltage can drop below V_{mpp} ± 5 % at STC.

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 °C ± 5 °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.

SOMMAIRE

AVANT-PROPOS 18
1 Domaine d'application 20
2 Références normatives 21
3 Termes et définitions 21
4 Échantillons d'essai 21
5 Marquage et documentation 21
6 Essais 21
7 Critères d'acceptation 21
8 Défauts visuels majeurs 21
9 Rapport 21
10 Modifications 22
11 Série et procédures d'essais 22
11.1 Examen visuel (MQT 01) 22
11.2 Détermination de la puissance maximale (MQT 02) 22
11.3 Essai diélectrique (MQT 03) 22
11.4 Mesurage des coefficients de température (MQT 04) 22
11.5 Section de l'espace réservé, précédemment NMOT 22
11.6 Performances dans les STC (MQT 06.1) 22
11.7 Performances sous faible éclairement (MQT 07) 22
11.8 Essai d'exposition en site naturel (MQT 08) 22
11.9 Essai de tenue à l'échauffement localisé (MQT 09) 22
11.9.1 Objet 22
11.9.2 Effet de l'échauffement localisé 23
11.9.3 Classification des interconnexions de cellules 23
11.9.4 Appareillage 23
11.9.5 Procédure 23
11.9.6 Mesurages finaux 23
11.9.7 Exigences 23
11.10 Essai de préconditionnement aux UV (MQT 10) 23
11.11 Essai de cycle thermique (MQT 11) 23
11.12 Essai humidité-gel (MQT 12) 24
11.13 Essai de chaleur humide (MQT 13) 25
11.13.1 Procédure 25
11.14 Essai de robustesse des sorties (MQT 14) 26
11.15 Essai de courant de fuite en milieu humide (MQT 15) 26
11.16 Essai de charge mécanique statique (MQT 16) 26
11.17 Essai à la grêle (MQT 17) 26
11.18 Essai de la diode de dérivation(MQT 18) 26
11.19 Stabilisation (MQT 19) 26
11.19.1 Définition de critères pour la stabilisation 26
11.19.2 Procédures de stabilisation induite par la lumière 26
11.19.3 Autres procédures de stabilisation 26
11.19.4 Stabilisation initiale (MQT 19.1) 26
11.19.5 Stabilisation finale (MQT 19.2) 27
11.20 Essai de charge mécanique cyclique (dynamique) (MQT 20) 27

11.21 Essai de dégradation induite par le potentiel (MQT 21) 27
11.22 Essai de flexion (MQT 22) 29

Figure 1 – Circulation de courant utilisant la méthode B de MQT 11 24
Figure 2 – Circulation de courant utilisant la méthode B de MQT 12 25
Figure 3 – Connexions électriques pour la méthode B de l'essai MQT 21, tension de réseau positive 28
Figure 4 – Connexions électriques pour la méthode B de l'essai MQT 21, tension de réseau négative 29

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 Cu(In,Ga)(S,Se)$_2$ à couches minces

AVANT-PROPOS

1) La Commission Électrotechnique Internationale (IEC) est une organisation mondiale de normalisation composée de l'ensemble des comités électrotechniques nationaux (Comités nationaux de l'IEC). L'IEC a pour objet de favoriser la coopération internationale pour toutes les questions de normalisation dans les domaines de l'électricité et de l'électronique. À cet effet, l'IEC – entre autres activités – publie des Normes internationales, des Spécifications techniques, des Rapports techniques, des Spécifications accessibles au public (PAS) et des Guides (ci-après dénommés "Publication(s) de l'IEC"). Leur élaboration est confiée à des comités d'études, aux travaux desquels tout Comité national intéressé par le sujet traité peut participer. Les organisations internationales, gouvernementales et non gouvernementales, en liaison avec l'IEC, participent également aux travaux. L'IEC collabore étroitement avec l'Organisation Internationale de Normalisation (ISO), selon des conditions fixées par accord entre les deux organisations.
2) Les décisions ou accords officiels de l'IEC concernant les questions techniques représentent, dans la mesure du possible, un accord international sur les sujets étudiés, étant donné que les Comités nationaux de l'IEC intéressés sont représentés dans chaque comité d'études.
3) Les Publications de l'IEC se présentent sous la forme de recommandations internationales et sont agréées comme telles par les Comités nationaux de l'IEC. Tous les efforts raisonnables sont entrepris afin que l'IEC s'assure de l'exactitude du contenu technique de ses publications; l'IEC ne peut pas être tenue responsable de l'éventuelle mauvaise utilisation ou interprétation qui en est faite par un quelconque utilisateur final.
4) Dans le but d'encourager l'uniformité internationale, les Comités nationaux de l'IEC s'engagent, dans toute la mesure possible, à appliquer de façon transparente les Publications de l'IEC dans leurs publications nationales et régionales. Toutes divergences entre toutes Publications de l'IEC et toutes publications nationales ou régionales correspondantes doivent être indiquées en termes clairs dans ces dernières.
5) L'IEC elle-même ne fournit aucune attestation de conformité. Des organismes de certification indépendants fournissent des services d'évaluation de conformité et, dans certains secteurs, accèdent aux marques de conformité de l'IEC. L'IEC n'est responsable d'aucun des services effectués par les organismes de certification indépendants.
6) Tous les utilisateurs doivent s'assurer qu'ils sont en possession de la dernière édition de cette publication.
7) Aucune responsabilité ne doit être imputée à l'IEC, à ses administrateurs, employés, auxiliaires ou mandataires, y compris ses experts particuliers et les membres de ses comités d'études et des Comités nationaux de l'IEC, pour tout préjudice causé en cas de dommages corporels et matériels, ou de tout autre dommage de quelque nature que ce soit, directe ou indirecte, ou pour supporter les coûts (y compris les frais de justice) et les dépenses découlant de la publication ou de l'utilisation de cette Publication de l'IEC ou de toute autre Publication de l'IEC, ou au crédit qui lui est accordé.
8) L'attention est attirée sur les références normatives citées dans cette publication. L'utilisation de publications référencées est obligatoire pour une application correcte de la présente publication.
9) L'attention est attirée sur le fait que certains des éléments de la présente Publication de l'IEC peuvent faire l'objet de droits de brevet. L'IEC ne saurait être tenue pour responsable de ne pas avoir identifié de tels droits de brevets et de ne pas avoir signalé leur existence.

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.

Le comité a décidé que le contenu de ce document ne sera pas modifié avant la date de stabilité indiquée sur le site web de l'IEC sous "http://webstore.iec.ch" dans les données relatives au document recherché. À cette date, le document sera

- reconduit,
- supprimé,
- remplacé par une édition révisée, ou
- amendé.

IMPORTANT – Le logo "colour inside" qui se trouve sur la page de couverture de ce document indique qu'elle contient des couleurs qui sont considérées comme utiles à une bonne compréhension de son contenu. Les utilisateurs devraient, par conséquent, imprimer ce document en utilisant une imprimante couleur.

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)$_2$ 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^{e} 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 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 éclairement (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 $Cu(In,Ga)(S,Se)_2$ 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 ≤ 25°C.

11.9.1 Objet

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