

TECHNICAL SPECIFICATION



Photovoltaic (PV) modules – Partial shade endurance testing for monolithically integrated products

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PHOTOVOLTAIC (PV) MODULES – PARTIAL SHADE ENDURANCE TESTING FOR MONOLITHICALLY INTEGRATED PRODUCTS

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IEC TS 63140 has been prepared by IEC technical committee 82: Solar photovoltaic energy systems. It is a Technical Specification.

The text of this Technical Specification is based on the following documents:

Draft	Report on voting
82/1804/DTS	82/1836/RVDTS

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

The language used for the development of this Technical Specification is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

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

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PHOTOVOLTAIC (PV) MODULES – PARTIAL SHADE ENDURANCE TESTING FOR MONOLITHICALLY INTEGRATED PRODUCTS

1 Scope

This document provides test methods for quantifying the permanent change in a monolithically integrated PV module's power output that may result from some potential partial shade conditions. Three tests are available, representing conditions of use, misuse, and most severe misuse. This document is applicable to monolithically integrated PV modules with one series-connected cell group or with multiple series-connected cell groups that are in turn connected in parallel. This document is not applicable to PV modules formed by the interconnection of separate cells.

With regard to shading, PV module documentation varies significantly by manufacturer. The physical tests prescribed in this document are applied without regard to manufacturer documentation or warranty policy, which may forbid certain shadows. The tests may therefore go beyond intended use, testing a module's response to misuse. The tests are accelerated tests. They are intended to excite similar levels of stress as shadows that are possible during an extended period of outdoor service. The tests represent adverse shadow scenarios, but not necessarily the worst case scenario, which varies by product. The procedures are performed repeatedly and in high-irradiance conditions; shadows occurring only one time or in low-irradiance conditions are likely to cause less damage. This test procedure does not comprehensively evaluate the efficacy or completeness of manufacturer recommendations. This test procedure is not equivalent to, and is not intended to replace, the hot-spot endurance test in IEC 61215-2. The safety aspects of partial shading of PV modules are covered by IEC 61730-2 MST 22 and IEC 61215-2 MQTS09.140:2021

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2 Normative references

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

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

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

IEC 60904-9, *Photovoltaic devices – Part 9: Classification of solar simulator characteristics*

IEC 60904-10, *Photovoltaic devices – Part 10: Methods of linear dependence and linearity measurements*

IEC TS 60904-13, *Photovoltaic devices – Part 13: Electroluminescence of photovoltaic modules*

IEC 61215-2:2021, *Terrestrial photovoltaic (PV) modules – Design qualification and type approval – Part 2: Test procedures*

IEC 61730-2, *Photovoltaic (PV) module safety qualification – Part 2: Requirements for testing*

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

IEC 61853-1, *Photovoltaic (PV) module performance testing and energy rating – Part 1: Irradiance and temperature performance measurements and power rating*

3 Terms and definitions

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

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

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>.

3.1

intended use

use of a product, process or product-related service in accordance with the information for use provided by the product manufacturer

3.2

misuse

use of a product, process or product-related service in a way not intended by the product manufacturer as described in the product manufacturer's product-specific manuals and operating instructions

Note 1 to entry: Module warranties are often voided in cases of misuse.

3.3

monolithically integrated

composed of multiple solar cells built on the same substrate or superstrate and integrated through scribing processes during fabrication

3.4

cell pitch

distance between successive repetitions of the monolithic integration pattern

3.5

module height

dimension of the module when measured parallel to the cell integration scribe lines

3.6

module width

dimension of the module when measured perpendicular to the cell integration scribe lines

3.7

string current

current that would pass in a long string of uniformly illuminated modules under the present irradiance conditions and at 25 °C

Note 1 to entry: String current is defined by:

$$I_s = I_{mp,STC} \frac{E_{POA}}{1000 \text{ W m}^{-2}}$$

where

$I_{mp,STC}$ is the current at maximum power listed on the module nameplate, and

E_{POA} is the plane-of-array irradiance.

Note 2 to entry: This formula is strictly valid only for linear devices, as defined in IEC 60904-10. It is acceptable for use in the range of irradiances and temperatures used in this document.

4 Principle

Monolithically integrated PV modules contain multiple PV cells connected in series. When illuminated and non-illuminated cells are connected in series, the non-illuminated cells can operate in reverse bias. In combination with nonuniformities in the device, this reverse bias can lead to highly nonuniform current flow, localized heating, and the formation of permanent shunts. The test procedures excite this nonuniform current flow and quantify the resulting permanent change in PV module power output.

Three test types are available, summarized in Table 1. Any of the tests may be requested by a requestor. The U test verifies the presence of specific warning text in manufacturer documentation. If this text is absent, test M is performed, whether or not it was requested. Test M approximates a person repeatedly walking past the module in sunny conditions. Test SM approximates a narrow tool, such as a cleaning machine, being repeatedly passed across the surface of the module. Selection of tests is summarized in Figure 1.

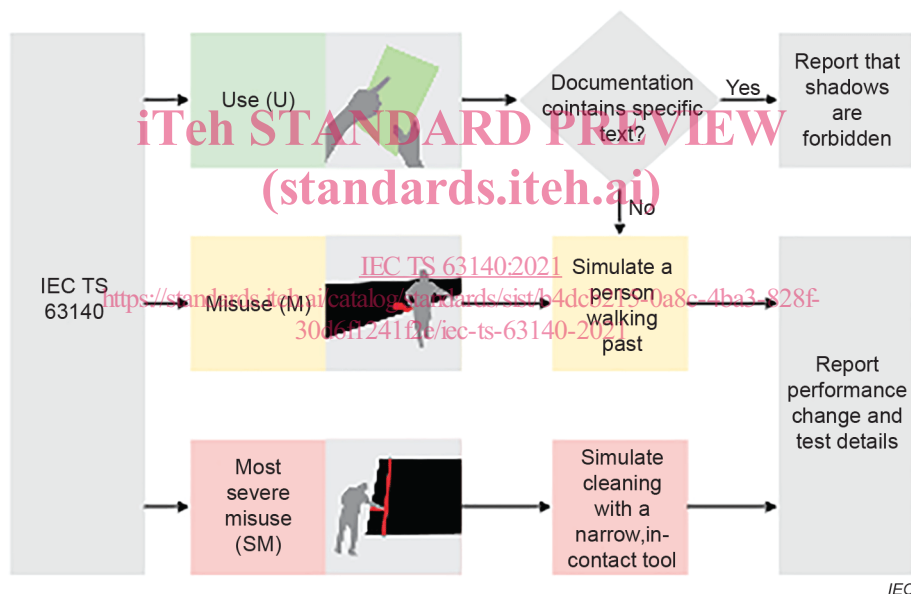


Figure 1 – Selection of the three available tests

Table 1 – Test types available in this document

Test name	Test summary	Explanation
Use (U)	Check documentation for the presence of specific warning text. If present, perform no testing. If absent, perform the misuse (M) test.	Assumes that all users understand the specific warning text and allow no potentially damaging shadows to be cast while current is flowing.
Misuse (M)	In high-irradiance conditions and with current flowing, repeatedly pass the human-sized mask (Figure 2, left) in front of the module.	Represents the following scenario. A person repeatedly walks past the module in clear, sunny conditions while current is flowing. The person casts their shadow in profile, with up to 1 m of their shadow's height overlapping the module. The person's shadow blocks direct irradiance but not diffuse irradiance, so about 90 % of incident light is blocked.
Most severe misuse (SM)	In high-irradiance conditions and with current flowing, repeatedly pass the narrow tool mask (Figure 2, right) in front of the module.	Represents the following scenario. A cleaning device repeatedly passes across the module in sunny conditions while current is flowing. The cleaning device is narrow and is in close contact with the module surface. The shadow extends across the entire height of the module and in parallel to the integration scribe lines. The shadow blocks both direct and diffuse irradiance, so about 100 % of incident light is blocked.

5 Apparatus

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If a procedure requiring physical testing is performed, the procedure requires:

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NOTE 1 In some cases test U (described below) can be completed without physical testing.

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- a) equipment for stabilizing module performance according to IEC 61215-2 MQT 19;
- b) equipment for measuring *I-V* curves according to IEC 61215-2 MQT 02, per IEC 60904-1;
- c) equipment for operating the PV module in a constant-current mode;
 - if the module under test contains a bypass diode, the electrical load equipment shall be able to sink current up to 1,5 times the module's nameplate I_{mp} ;
 - if the module under test does not contain a bypass diode, the electrical load equipment shall be able to both source and sink current up to 1,5 times the module's nameplate I_{mp} , at whatever voltage (up to the maximum string voltage) is required to do so;
- NOTE 2 The voltage required to ensure that I_{mp} is flowing at all times during the test varies by product, and may be negative (reverse bias) when the mask is on the module.
- the current passed by the load equipment shall be updated to accommodate changes in irradiance and these updates shall be frequent enough that changes in irradiance never exceed 5 % between updates;
- d) equipment for mounting the module outdoors in natural sunlight or a class CCC or better continuous solar simulator, in compliance with IEC 60904-9;
- e) a radiometer (pyranometer or reference cell meeting the requirements of IEC 60904-2) for measuring irradiance incident on the module plane in the continuous solar simulator or in natural sunlight;
- f) one or more masks conforming to the requirements below for one or more tests selected from Table 1:
 - for test M, a mask roughly approximating the shape of a human body (from thigh to head, approximated by a rectangle for ease of fabrication, conforming to the dimensions in Figure 2) and blocking 88 % to 92 % of incident light;

NOTE 3 Mask M blocks approximately 90 % of incident light, because a shadow cast outdoors by a distant object blocks only direct sunlight, and in clear conditions this is approximately 90 % of incident light.