

TECHNICAL SPECIFICATION

SPECIFICATION TECHNIQUE



Photovoltaic concentrator cell documentation

ITIH STANDARD PREVIEW
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Documentation relative aux cellules photovoltaïques à concentration

IEC TS 62789:2014

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

Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00
info@iec.ch
www.iec.ch

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CONTENTS

FOREWORD.....	4
1 Scope and object.....	6
2 Normative references	6
3 Specifications for concentrator cells	6
4 Concentrator cell characterization	8
4.1 Overview.....	8
4.2 Product identity.....	8
4.2.1 General	8
4.2.2 Manufacturer	9
4.2.3 Model number.....	9
4.2.4 Type of cell.....	9
4.3 Product description	9
4.3.1 General	9
4.3.2 Total chip area.....	9
4.3.3 Designated illumination area.....	10
4.3.4 Nominal efficiency and design irradiance	10
4.3.5 Nominal current ratios	11
4.3.6 Temperature coefficients	11
4.3.7 Front metallization.....	11
4.3.8 Back metallization	11
4.3.9 Antireflection coating design.....	11
4.3.10 Thickness of substrate	11
4.4 Cell processing and use conditions.....	11
4.4.1 Recommended cell operating temperature.....	11
4.4.2 Maximum cell photocurrent.....	12
4.4.3 Recommended cell processing temperature.....	12
4.4.4 Chemical compatibilities/incompatibilities	12
4.4.5 Storage conditions.....	12
4.4.6 Recommended bonding method.....	12
4.5 Graphs and tables.....	12
4.5.1 Typical I-V curve.....	12
4.5.2 Efficiency versus irradiance	13
4.5.3 Vmp versus irradiance	13
4.5.4 Quantum efficiency	14
4.5.5 Angular responsivity	16
4.6 Cell testing.....	17
Bibliography.....	18
Figure 1 – Total cell area and designated illumination area.....	10
Figure 2 – Example current-voltage graph.....	12
Figure 3 – Example graph of efficiency as a function of irradiance	13
Figure 4 – Example graph showing voltage as a function of irradiance.....	13
Figure 5 – Example graph of external quantum efficiency	14
Figure 6 – Example graph showing response as a function of the angle of incidence	17

Table 1 – Specification template 7
Table 2 – Example tabulation of quantum efficiency data 14

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PHOTOVOLTAIC CONCENTRATOR CELL DOCUMENTATION

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Technical specifications are subject to review within three years of publication to decide whether they can be transformed into International Standards.

IEC TS 62789, which is a technical specification, has been prepared by IEC technical committee 82: Solar photovoltaic energy systems.

The text of this technical specification is based on the following documents:

Enquiry draft	Report on voting
82/776/DTS	82/821/RVC

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

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

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

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PHOTOVOLTAIC CONCENTRATOR CELL DOCUMENTATION

1 Scope and object

This Technical Specification provides guidelines for the parameters to be specified for concentrator photovoltaic cells (both multijunction and single junction) and provides recommendations and references for measurement techniques. No attempt is made to determine pass/fail criteria for cells.

The purpose of this specification is to define the performance and physical characteristics of concentrator cells. This specification may also be used for describing cell assemblies and receivers, but is not written to specifically address cell packaging. It is not intended to standardize the properties of the concentrator cells, but to standardize how the properties are communicated.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

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IEC TS 62789:2014

IEC 62787, *Concentrator photovoltaic (CPV) solar cells and cell-on-carrier (COC) assemblies – Reliability qualification*¹

3 Specifications for concentrator cells

All concentrator cell datasheets complying with this specification shall provide, as part of their product marking and documentation, the information specified in Table 1 below. See subsequent clauses and subclauses of this Technical Specification for further explanation of individual specifications. In addition to the information indicated by the examples, it is required to include a sketch of the cell and the indicated graphs.

Some of the specifications are optional; however, if a concentrator cell manufacturer chooses to include optional information, it should be reported and measured using the definitions provided in this Technical specification.

¹ To be published.

Table 1 – Specification template

Characteristic	Example	Notes/Section
Product identification		4.2
Manufacturer	The XYZ Company	4.2.2
Model number	XX1090	4.2.3
Type of cell	Three junction: GaInP (1,89 eV) / GaInAs (1,39 eV) / Ge (0,67 eV) on germanium substrate	4.2.4
Product description		4.3
Total area	$(1,1 \pm 0,003) \text{ cm} \times (1 \pm 0,003) \text{ cm}$	4.3.2
Designated illumination area	$(1 \pm 0,003) \text{ cm} \times (1 \pm 0,003) \text{ cm}$ (see example Figure 1)	4.3.3
Simulator performance-defining area	$1,01 \pm 0,006 \text{ cm}^2$	
Nominal efficiency at design irradiance	$39 \% \pm 2 \% \text{ at } 500 \text{ kW/m}^2$	4.3.4
Nominal current ratios	Current ratios under G173 direct spectrum (relative to top junction current): 1,89 eV cell = 1 1,39 eV cell = $1,0 \pm 0,03$ 0,67 eV = $1,7 \pm 0,03$	4.3.5
Temperature coefficients (measured at the irradiance for which the product was designed)	$\alpha = \text{dIsc}/\text{dT} = + (0,11 \% \pm 0,03 \%)/\text{K}$ when 1,89 eV-cell limited; $+ (0,07 \% \pm 0,03 \%)/\text{K}$ when 1,39 eV-cell limited; $\beta = \text{dVoc}/\text{dT} = - (0,15 \% \pm 0,02 \%)/\text{K}$ $\text{dPmax}/\text{dT} = - (0,24 \% \pm 0,06 \%)/\text{K}$ Measured at $1\,000 \text{ kW/m}^2$; AM1,5 direct; temperature range of 25°C to 70°C . Other conditions may also be documented.	4.3.6
Front metallization	Silver	4.3.7
Front metallization thickness	$1 \mu\text{m}$	4.3.7
Back metallization	Gold	4.3.8
Anti-reflection coating design	Matched to index of 1.4	4.3.9
Thickness of substrate	$150 \mu\text{m}$	4.3.10
Cell processing and use conditions		4.4
Recommended operating (cell) temperature	$-20^\circ\text{C} < T < 150^\circ\text{C}$	4.4.1
Maximum photocurrent	1 A/cm^2	4.4.2
Recommended processing temperature	$< 350^\circ\text{C}$ for 10 min	4.4.3
Chemical compatibilities/ incompatibilities	Incompatible with aqua regia	4.4.4
Storage conditions (shelf life, humidity, temperature, and atmosphere)	Storage $10^\circ\text{C} < T < 30^\circ\text{C}$ $20 \% < \text{RH} < 70 \%$ Shelf life < 4 months Atmosphere = air	4.4.5
Recommended bonding method	Front side: wire bonding Back side: solder	4.4.6
Electrostatic discharge threshold		As measured in future IEC 62787

Characteristic	Example	Notes/Section
Graphs/Tables		4.5
Typical I-V curve (measured at the irradiance for which the product was designed, AM1,5 Direct spectrum, 25 °C). Isc, Imp, Vmp, Voc, FF, Efficiency specified	See example Figure 2 NOTE It is requested that irradiance be specified in units of kW/m ² , since these units also indicate the approximate concentration	4.5.1
Efficiency as function of irradiance at 25 °C	See example Figure 3 NOTE It is requested that irradiance be specified in units of kW/m ² , since these units also indicate the approximate concentration	4.5.2
Voltage at maximum power point as a function of irradiance at 25 °C	See example Figure 4 NOTE It is requested that irradiance be specified in units of kW/m ² , since these units also indicate the approximate concentration	4.5.3
Quantum efficiency (presented as either a graph or a table). One curve for each junction, measured at 25 °C	See example Figure 5	4.5.4
Angular responsivity, Isc as a function of incidence angle compared with cosine function	See example Figure 6	4.5.5
Cell testing		4.6
LIV and other characterization testing: Note conditions for testing and sampling rate	500 kW/m ² ; AM1,5D; 25 °C; 100 % of samples	Example only; refer to description in 4.6
Stress testing: Describe stress testing that is applied and sampling rate, if applicable	Certification to future IEC 62787 IEC TS 62789:2014	Example only; refer to description in 4.6

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4 Concentrator cell characterization

4.1 Overview

This clause describes parameters and guidelines for characterizing concentrator cells, with one subclause for each entry in Table 1. It is useful for datasheets to present similar types of information and the primary purpose of this Technical Specification is to facilitate consistency between datasheets. However, recognizing that the information that is presented represents a typical cell rather than a specific cell, small variations in testing methodology may be unimportant. The focus of this specification is to provide consistent definitions of test conditions rather than to specify precise methods for the measurements. In the future, it may be useful to define the measurement techniques in more detail, but there is not yet consensus on all of the details of the measurements. For example, characterizing/controlling the spectrum as a function of time and location during the flash of a simulator can be quite challenging and each lab has its own method for controlling the spectrum. Some of the measurements described in this specification may have uncertainties on the order of 5 % to 10 %. Defining careful measurement techniques that can reduce these uncertainties will be useful, but is outside of the scope of this specification.

4.2 Product identity

4.2.1 General

The datasheet shall unambiguously define the identity of the product. This may become especially confusing if a different model number is used for a concentrator cell and a mounted cell.

4.2.2 Manufacturer

In some cases, multiple manufacturers may be involved for the epitaxial growth, cell processing, and cell testing. The name of the manufacturer should identify the company that is responsible for the creation of the datasheet.

4.2.3 Model number

The model number should be unique to the described product.

4.2.4 Type of cell

The description of the cell should include at a minimum:

- The number of junctions
- The material(s) used for each junction
- The band gap associated with each junction if this is not clear from the material (e.g. silicon needs no clarification)
- The substrate

Optionally, the thicknesses of each of the layers may also be included.

4.3 Product description

4.3.1 General

A drawing is needed to define the sample geometry.

4.3.2 Total chip area

The total cell (chip) area is needed for designing cell assemblies and how cells will be implemented into CPV modules. The total area designation should include the dimensions (e.g. 1 cm × 1,1 cm) and a sketch. The sketch should include the total chip dimensions as well as the inactive areas that are both metallized and unmetallized. Figure 1 is an example, including an expanded view of the lower right corner; the cell manufacturer may use a different method to communicate the correct geometry.

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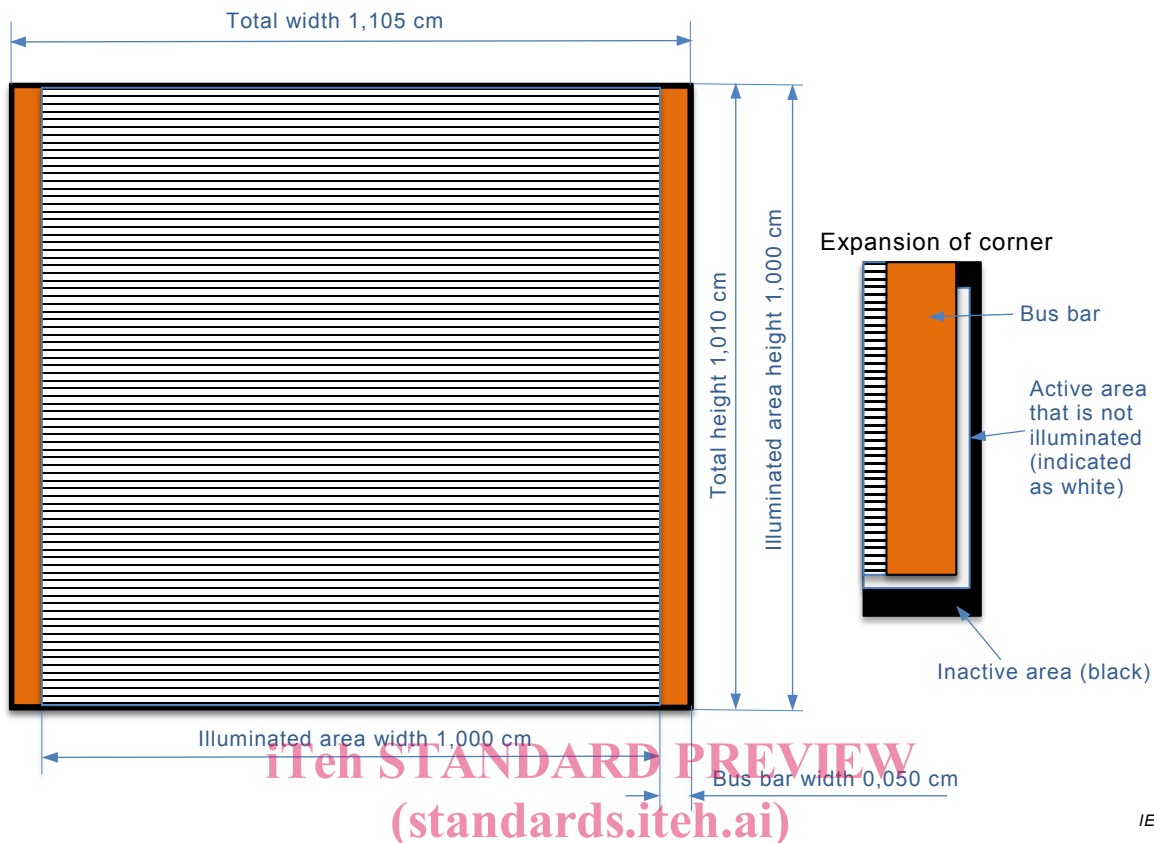


Figure 1 – Total cell area and designated illumination area
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4.3.3 Designated illumination area

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In contrast to flat-plate cells that are usually 100 % illuminated, the design of many concentrator systems allows for the cells' contacts to be made outside of the illuminated area. On the datasheet, the sketch should include indication of the location and dimensions of the designated illumination area, referring to the area that is designed to be illuminated, including the area of grid lines and busbars that are intended to be illuminated. The dimensions of the busbar that will be used for electrical contact should be well defined. This can be confusing because some concentrator cells include an area that responds to illumination but that is not intended to be illuminated. Specifically, to prevent shorting, busbars are often designed to leave a lip that is light active but will lie outside of the optical path. Thus, light-active areas that are not intended to be illuminated should be masked during the measurement process, or, a mathematical correction may be applied using the area on the simulator performance-definition area.

Simulator performance-definition area (area that is illuminated during test) = [area inside mesa isolation or cell edge (if no mesa)] – [busbars or bond pads].

Designated illumination area = the area designed to be illuminated between busbars and mesas or cell edge.

4.3.4 Nominal efficiency and design irradiance

The nominal efficiency should be reported for a typical cell measured under the following conditions:

- Design irradiance kW/m²
- AM1,5 Direct (as specified in IEC 60904-3), and
- 25 °C cell temperature.

The design irradiance is also specified. Methods for measuring I-V curves can be found in references listed above. The uncertainty of the measurement should be estimated and included.

4.3.5 Nominal current ratios

The photocurrents for each junction within a multijunction cell can be measured by adjusting the spectrum or by integrating the quantum efficiency curve convoluted with the spectrum of interest. The expected current ratios should be specified for the IEC 60904-3 direct reference spectrum measured at 25 °C in air (for the described package). If the product is a bare cell that will be encapsulated it could be useful to quote the values for measurement with the encapsulation, but this could become confusing since applying encapsulation, protective glass and/or secondary optics could change the optics. If such information is supplied, it should be clearly labelled as to how it was measured. By convention, the top cell will be considered to have a relative current of unity and the ratios of the currents for each of the other subcells are noted relative to the top-cell current. The ratios will apply to the same measurement conditions used to determine the nominal efficiency. The variability of these ratios should be reflected in the indication of the uncertainty. The junction identification should match the description of the cell in an unambiguous way by specifying the band gap, composition, junction number or other unique identifier.

4.3.6 Temperature coefficients

The temperature coefficients for the V_{oc} (open-circuit voltage) and P_{max} (maximum power) can be obtained by measuring the I-V curves for the cell under the irradiance for which the cell was designed and AM1.5 Direct illumination for a set of temperatures spanning a range of at least 70 °C and/or within the full operating temperature range, as specified by the manufacturer (see 4.4.1). The temperature coefficient of the I_{sc} (short-circuit current) is especially difficult to measure and may best be reported from literature values or from integration of the quantum efficiency measured at variable temperatures considering bandgap lowering with increased temperature. All temperature coefficients should be expressed in relative units (%/K) and uncertainties included. Temperature coefficients for multiple irradiance levels may be included at the discretion of the manufacturer.

4.3.7 Front metallization

The chemical composition and thickness of the front metallization should be described with enough detail to facilitate contact formation.

4.3.8 Back metallization

The chemical composition of the back metallization should be described with enough detail to facilitate contact formation.

4.3.9 Antireflection coating design

Specify the index of refraction that the antireflection coating was designed to match to (for example, to air ($n = 1$)).

4.3.10 Thickness of substrate

The thickness of the substrate should be specified.

4.4 Cell processing and use conditions

4.4.1 Recommended cell operating temperature

If the cell operating temperature is increased, it may cause premature failure of the cells. Operation at very low temperatures may become problematic if the tunnel junction function becomes limited. The manufacturer should identify a recommended operating range.